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A Seismic Data Catalog and Associated Graphical Capabilities

T. N. Bishop
H. P. Foote
S. C. Blair

November 1979

Prepared for the U.S. Department of Energy under Contract EY-76-C-06-1830

Pacific Northwest Laboratory
Operated for the U.S. Department of Energy by Battelle Memorial Institute

PNL-2893

Battelle

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Pacific Northwest Laboratory
Richland, Washington 99352

SUMMARY

To facilitate the use of the enormous amount of earthquake data presently available, Pacific Northwest Laboratory (PNL) has formed an extensive data base of compiled seismic data. PNL has also developed many useful and unique computer techniques for analysis and display of the data. These techniques could be used in many areas of the United States to support nuclear waste management and other energy-related activities.

Software associated with the data base includes programs for editing earthquake files; sorting files with respect to time, location, or magnitude; selecting data using various parameters; and merging files. These techniques allow the rapid formation of data files that are tailored to specific interests. The desired file may then be listed or displayed graphically using PNL's diversified graphic capability.

From the data analysis software, an accurate and comprehensive earthquake catalog for the Pacific Northwest was created. This catalog was produced by merging data from many sources and includes microearthquake data. Duplicate events were eliminated, while all information available for a particular event was retained.

Graphic displays can plot two- and three-dimensional epicenter or hypocenter information. Magnitude and/or depth information can be represented on two-dimensional plots by using color or symbol size. Plots can be produced using a variety of map projections and at a specified scale. This allows the use of any desired map as a base map for the display of earthquake data. Additional information such as rivers, coastlines, faults, and boundaries may also be included on the plots. Data may also be displayed using normal or two-dimensional histograms.

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ACKNOWLEDGMENTS

The aid of Valerie Coburn is gratefully acknowledged in the manual identification of duplicate earthquakes. Carl Von Hake of NOAA, Gary Rogers of the Dominion Observatory, Richard Couch of Oregon State, and George Rothe formerly of the University of Washington helped in specific cases. Norm Rasmussen of the University of Washington, in particular, was helpful in identification of duplicates by searching through older seismograph records.

INTRODUCTION

Knowledge of seismic activity is an important aspect of site evaluation for energy-related facilities such as nuclear reactors, nuclear waste repositories and dams. Over the past several years continued improvement of seismic sensing, recording, and analysis techniques has created a sizable catalog of earthquake data for the United States. Access to this type of data is central to any thorough seismic analysis.

Much of the earthquake data collected to date have been compiled and are readily available in digital form. Several large compilations are available which contain thousands of earthquakes on a global scale. These data sets are of variable quality and do not usually include microearthquake data. Other compilations do include microearthquake data. These compilations contain high quality data that is specific to a particular geographic area.

Analysis of seismicity for a given region often requires data from more than one compilation. Earthquake data are generally available on computer cards or magnetic tape. Unfortunately, use of one or more compilation requires reformatting of information and elimination of numerous duplicate events.

To provide a better method for retrieving and analyzing earthquake data, Pacific Northwest Laboratory (PNL) developed a seismic data base with the capability to produce seismic catalogs that are superior in completeness and accuracy to those presently available. The data base incorporates several compilations of seismic data and is applicable to all areas of the United States. In addition, PNL developed computerized statistical and graphic techniques for sophisticated analysis of seismic data.

Software associated with the data base includes programs for editing of earthquake files; sorting files with respect to time, location, or magnitude; selecting data using various parameters; and merging files. These techniques allow the rapid formation of data files that are tailored to specific interests.

Graphic displays include two- and three-dimensional epicenter or hypocenter plots. Magnitude and/or depth information can be represented on two-dimensional plots by using color and symbol size. An important aspect of the graphics techniques is the flexibility of the output. Plots can be made on any one of the graphic display devices shown in Figure 1. Earthquake data can also be plotted along with many other types of data such as rivers, coastlines, faults, and state and national boundaries. In addition, the projection, scale and geographic location within the study area can be easily modified. This allows the use of any desired map as a base map for the display of the earthquake data.

From the data analysis software, an accurate and comprehensive earthquake catalog for the Pacific Northwest was created. This catalog was produced by merging data from many sources and includes microearthquake data. Duplicate events were eliminated, while all information available for a particular event was retained. This earthquake catalog is the most complete and accurate documentation available for earthquake activity in the Pacific Northwest region and should be very useful in the evaluation of seismic activity for the design criteria of energy-related installations in the Pacific Northwest.

This report documents both the development of the Pacific Northwest Seismic Catalog and the computer programs that are available to process the seismic data. Analytical procedures for merging data catalogs and eliminating duplicate events are explained. Graphic capabilities compatible with the earthquake data are also described. Details of the seismic data file structure and computer programs are presented in the Appendix.

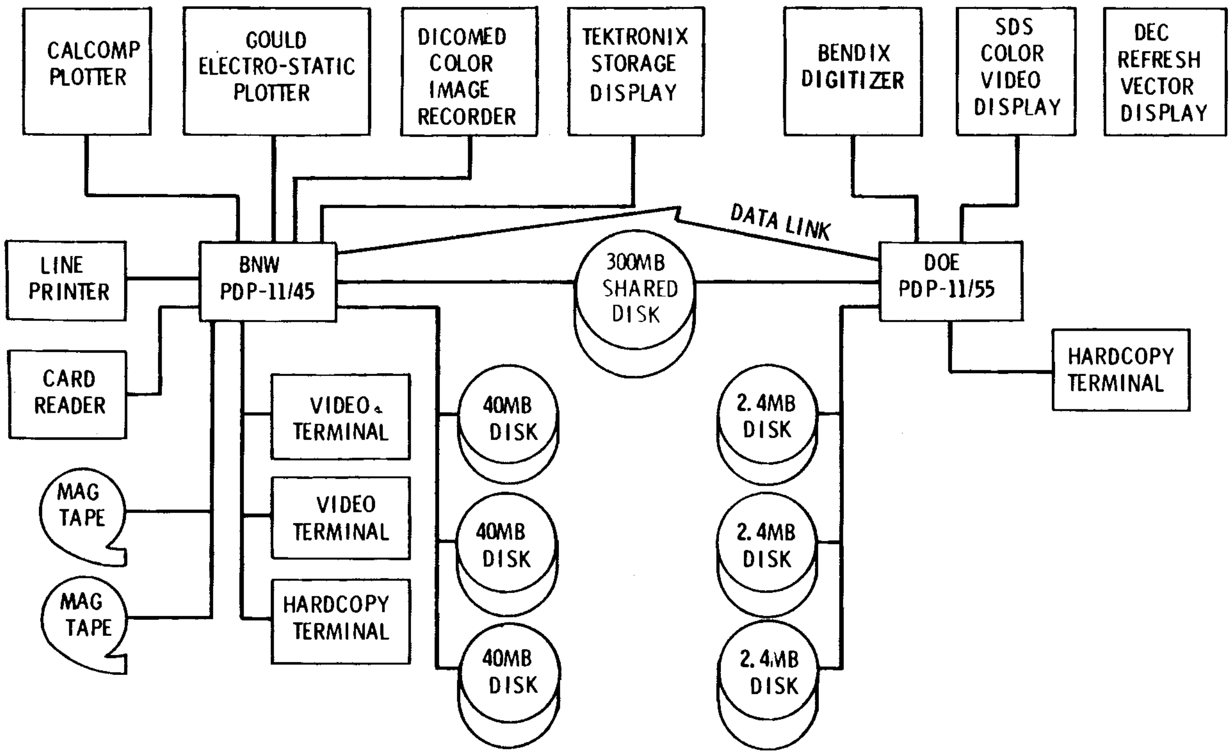


FIGURE 1. PNL Computing Facility

RECOMMENDATIONS

The PNL Seismic Data Base coupled with the associated analytical programs and graphic display capability constitutes a valuable tool for analysis of earthquake data. Now that this tool is operational, necessary action must be taken to facilitate its application to specific seismic problems. The following paragraphs describe past usage of the PNL seismic package and present recommendations for implementation and further development of this tool.

Past uses of the seismic analytical package include:

- preparation of stereographic hypocenter maps displaying earthquake data in the San Francisco Bay area. These plots were produced for the United States Geological Survey and provided three-dimensional views of the earthquake hypocenters.
- preparation of maps for the U.S. Army Corps of Engineers that displayed earthquake epicenters along with dam locations in Washington, Idaho, and Western Montana.
- use of the data base in preparing epicenter maps for several nuclear waste isolation studies.

A wider exposure to the seismic community is necessary if this tool is to be used effectively and a marketing program is recommended. Continued development of this tool is also necessary in order to make it more versatile and useful and thus more marketable. Primary areas of development which should yield fruitful results are:

1. capability to display seismicity chronologically, scaled in time
2. addition of data, in particular:
    a. microseismic data at nuclear reactor sites across the country
    b. other known earthquake data sets, such as a New England data set at Boston College, the data files of the International Seismological Centre and the Japan Meterological Agency

c. historical data sets published in the Bulletin of the Seismological Society of America
d. nationwide fault data
e. population data base
f. dam data base
g. detailed and complete seismic data at the potential nuclear waste repository sites
h. crustal structure data from seismic refraction and reflection measurements
i. regional gravity data

3. a program to migrate earthquakes to the surface along a fault plane and map the resulting surface location
4. long-term statistical analysis studies of historical data, such as in China, Turkey, and Persia.

PACIFIC NORTHWEST SEISMIC CATALOG

The earthquake data in PNL's Pacific Northwest catalog were compiled from a variety of sources. The total combined catalog presently includes 5,548 events and covers an area from 103° to 135° west longitude and from 41° to 52° north latitude (Figure 2). The time period covered by the data base extends from November 22, 1827, to March 31, 1978. Primary sources of data are: the Woodward-Clyde 1975 seismic catalog (furnished by Dr. D. Tillson of Washington Public Power Supply System); the National Earthquake Information Service (NEIS) world seismicity tape [purchased from the National Oceanic and Atmospheric Administration (NOAA)]; the Canadian Dominion Observatory seismicity tape (furnished by Dr. R. Riddihough and Dr. G. Rogers of the Victoria Observatory); the California 1900-1974 seismicity tape (purchased from the California Division of Mines and Geology, which has merged data from the USGS, Berkeley, and the California Institute of Technology); microearthquake data in Eastern Washington (furnished by Dr. S. Malone of the University of Washington); and microearthquake data in Western Washington (furnished by Dr. R. Crosson of the University of Washington). Table 1 describes each source in more detail. Figures 3 through 7 show the epicenter locations of the data in each data base.

To form the Pacific Northwest Seismic Catalog, data from the above sources were combined and placed in chronological order. Thousands of duplicate events occurred in this merged file. Duplicates occurred because many events were listed in more than one source, and some sources listed an event more than once. In particular, Woodward-Clyde did not attempt to identify multiple listings in its catalog. The Canadian data base also listed more than one description per event (when available) after 1968.

For the PNL catalog, duplicate events were eliminated in a two-step process. First, obvious duplicates (time matching with 2 sec and locations matching within 1 degree) were found and erased automatically. Secondly, possible duplicates were identified with a program which compared location coordinates, origin time, and magnitude and/or intensity. This program printed out these parameters along with depth, explosion code, and source for each of the

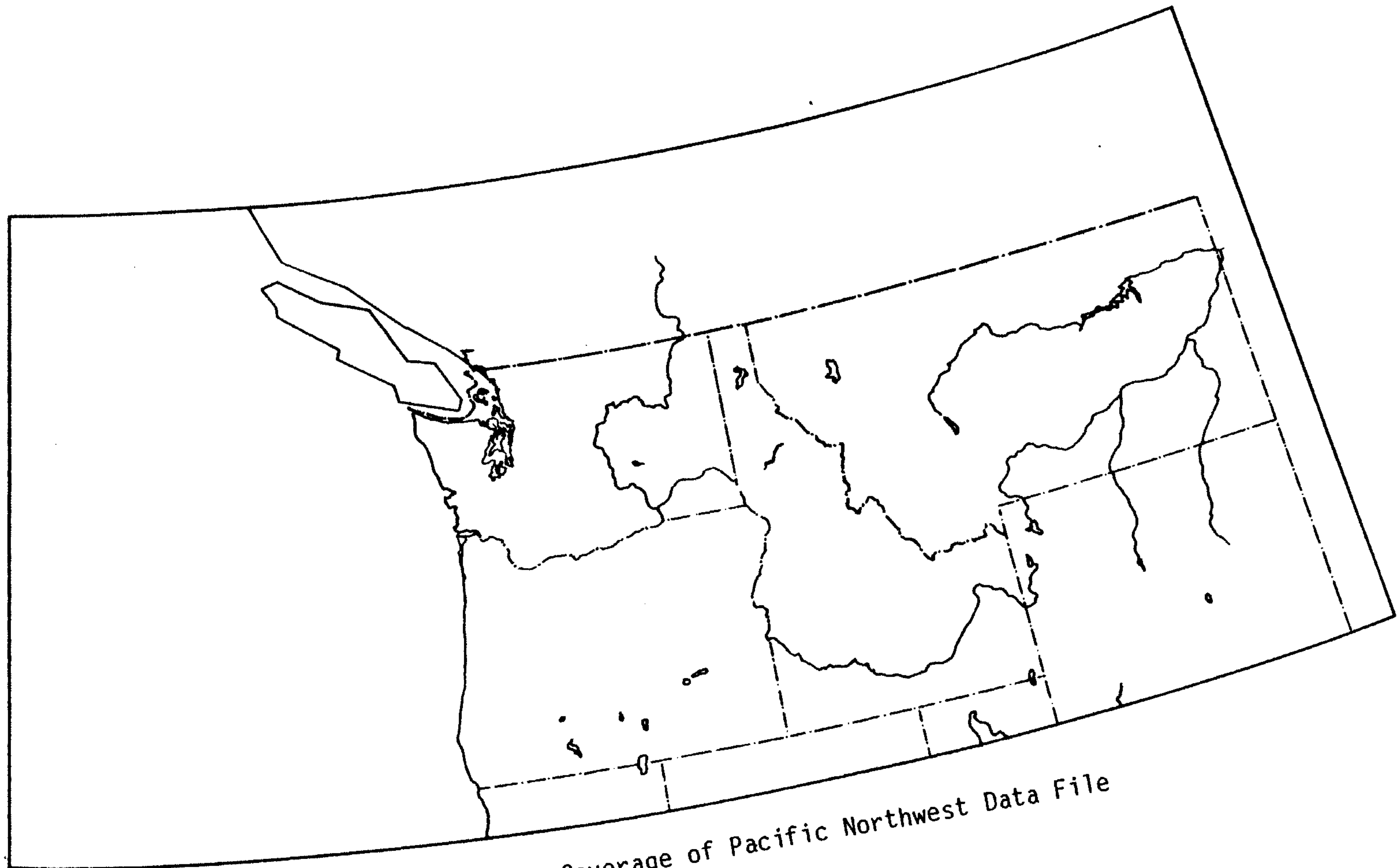


FIGURE 2. Area Coverage of Pacific Northwest Data File

TABLE 1. Sources of Data for the Pacific Northwest Seismic Catalog

Data Source	Symbol	Years	Location	Typical Resolution	Magnitude Range	Number of Events[a]
Woodward-Clyde	P	1827-1975	110°-128°W 41°-55°N	(Catalog)	All	2133
NOAA	N	1628-1977	World	(Catalog) (30 km since 1950)	>3.0	2740
Canada (Dominion Observatory)	C	1568-1975	150°-40°W 40°-90°N	(Catalog) (30 km for events (near Vancouver)	All	2889
Eastern Washington (Dr. Malone - U.W.)	E	1969-1978	117°-121°W 41°-49°N	3 km	>2.5[b]	248
Western Washington (Dr. Crosson - U.W.)	W	1970-1977	121°-125°W 41°-50°N	3 km	>2.5[b]	284
California (Bureau of Mines and Geology)	L	1900-1974	California and area 100 km from state border	15 km	All	153

(a) In our Range (103°-135°W, 41°-52°N), before duplicates were discarded.
(b) Cut off all events below 2.5.

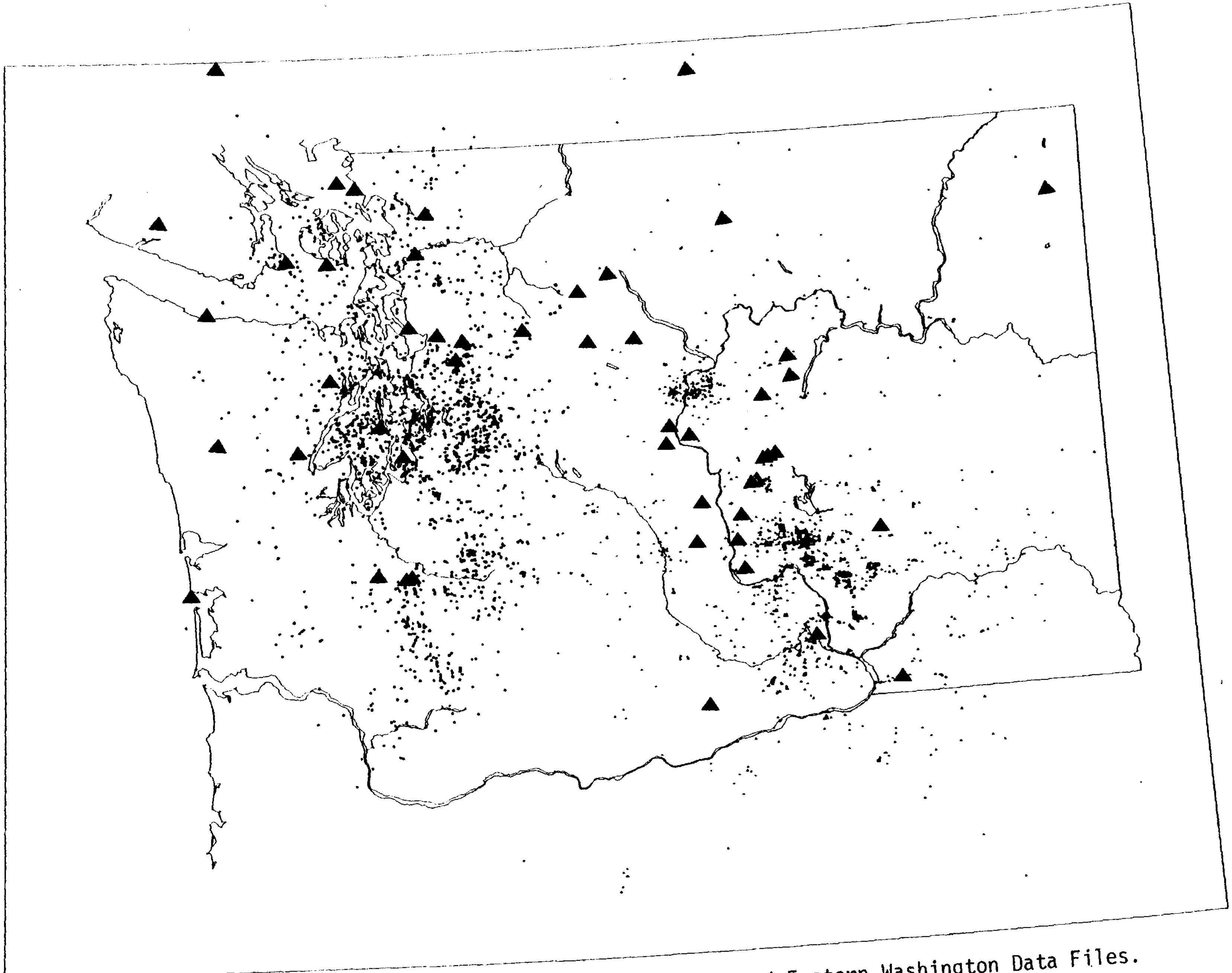


FIGURE 3. Microearthquake Epicenters from the Western and Eastern Washington Data Files. Triangles indicate seismic recording station locations.

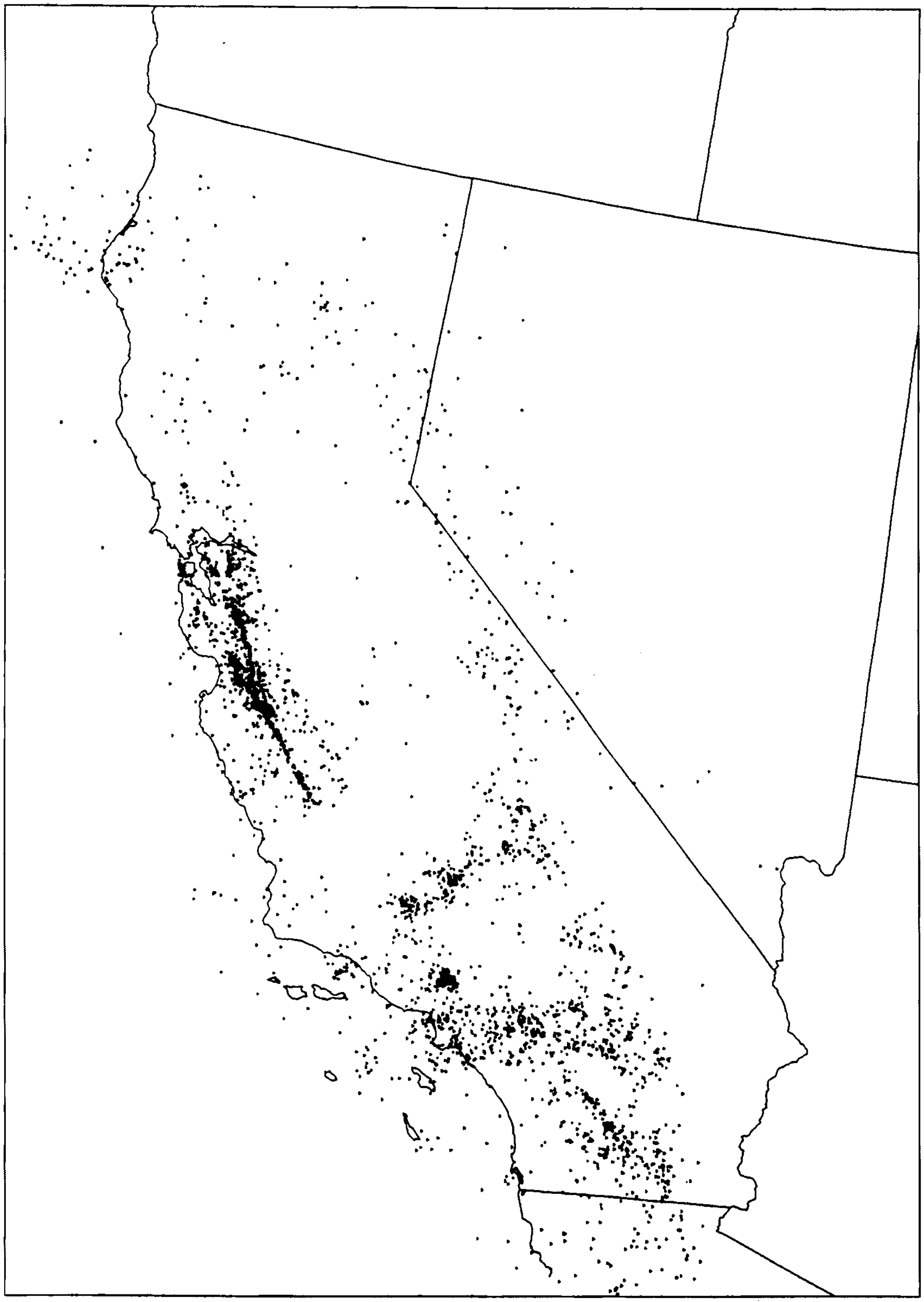


FIGURE 4. Earthquake Epicenters from the California Data File (1/10 of Events Plotted)

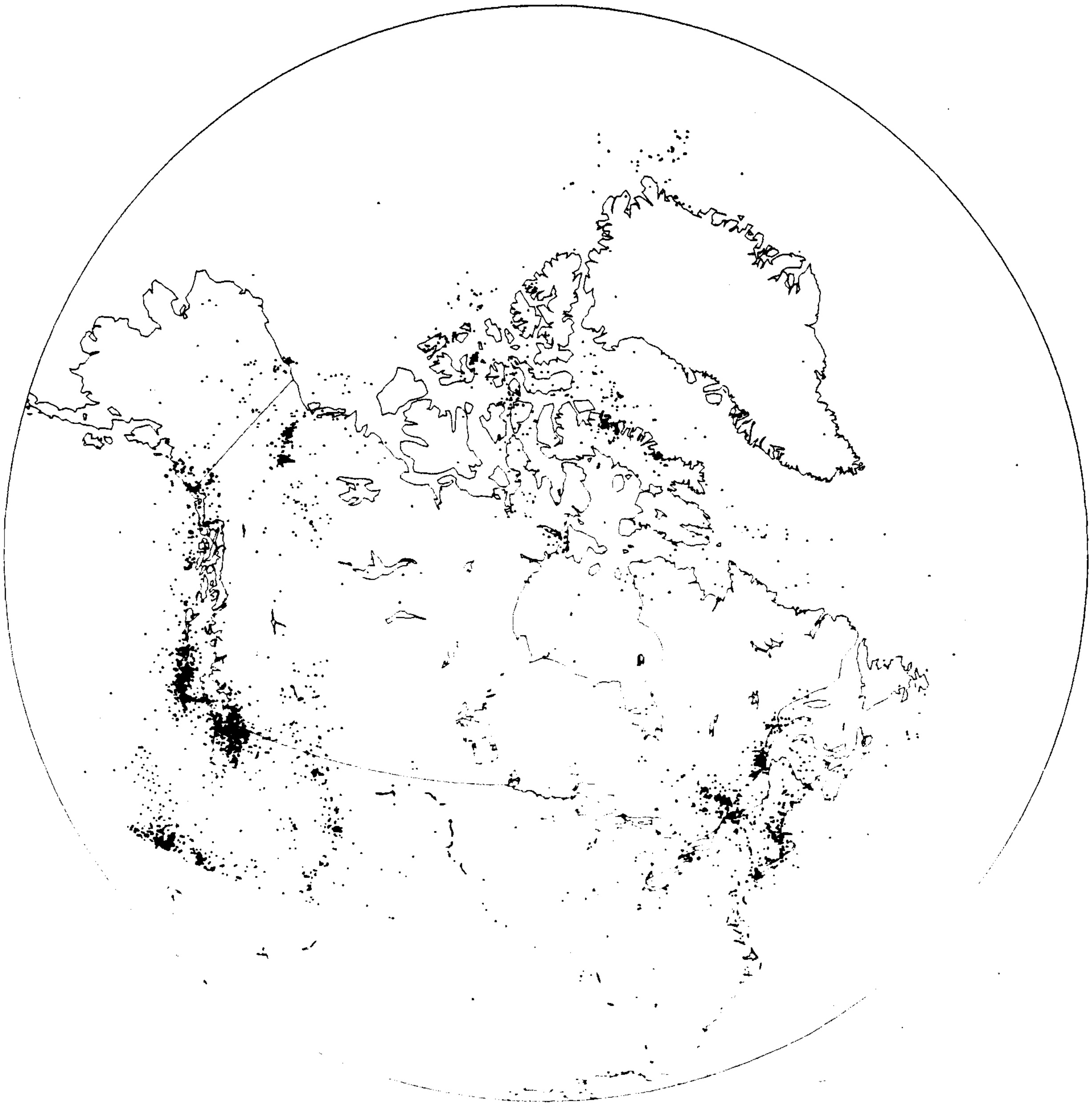


FIGURE 5. Earthquake Epicenters from the Canadian Data File (1/2 of Events Plotted)

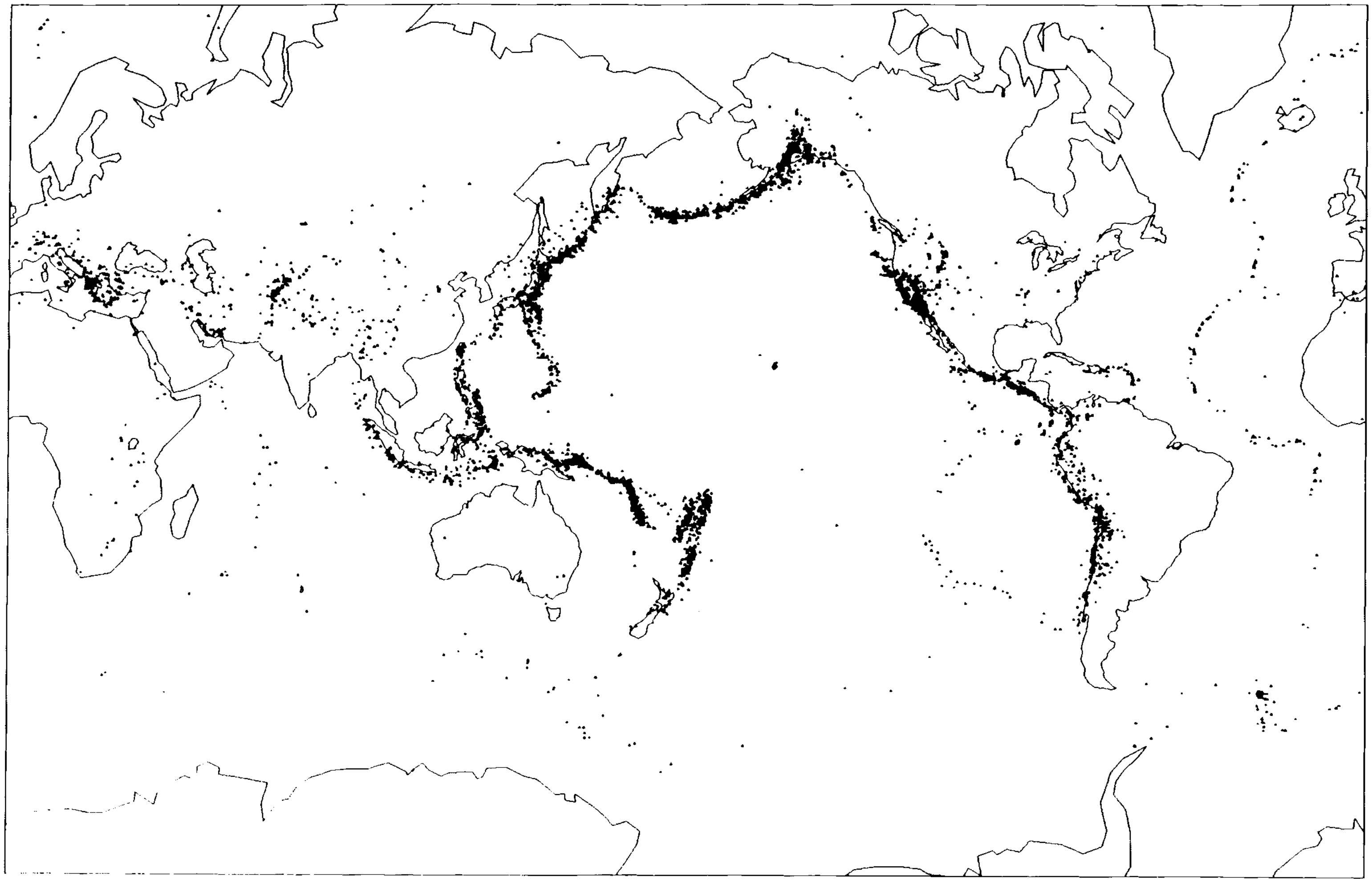


FIGURE 6. Earthquake Epicenters from the NOAA World Data File (1/25 of Events Plotted)

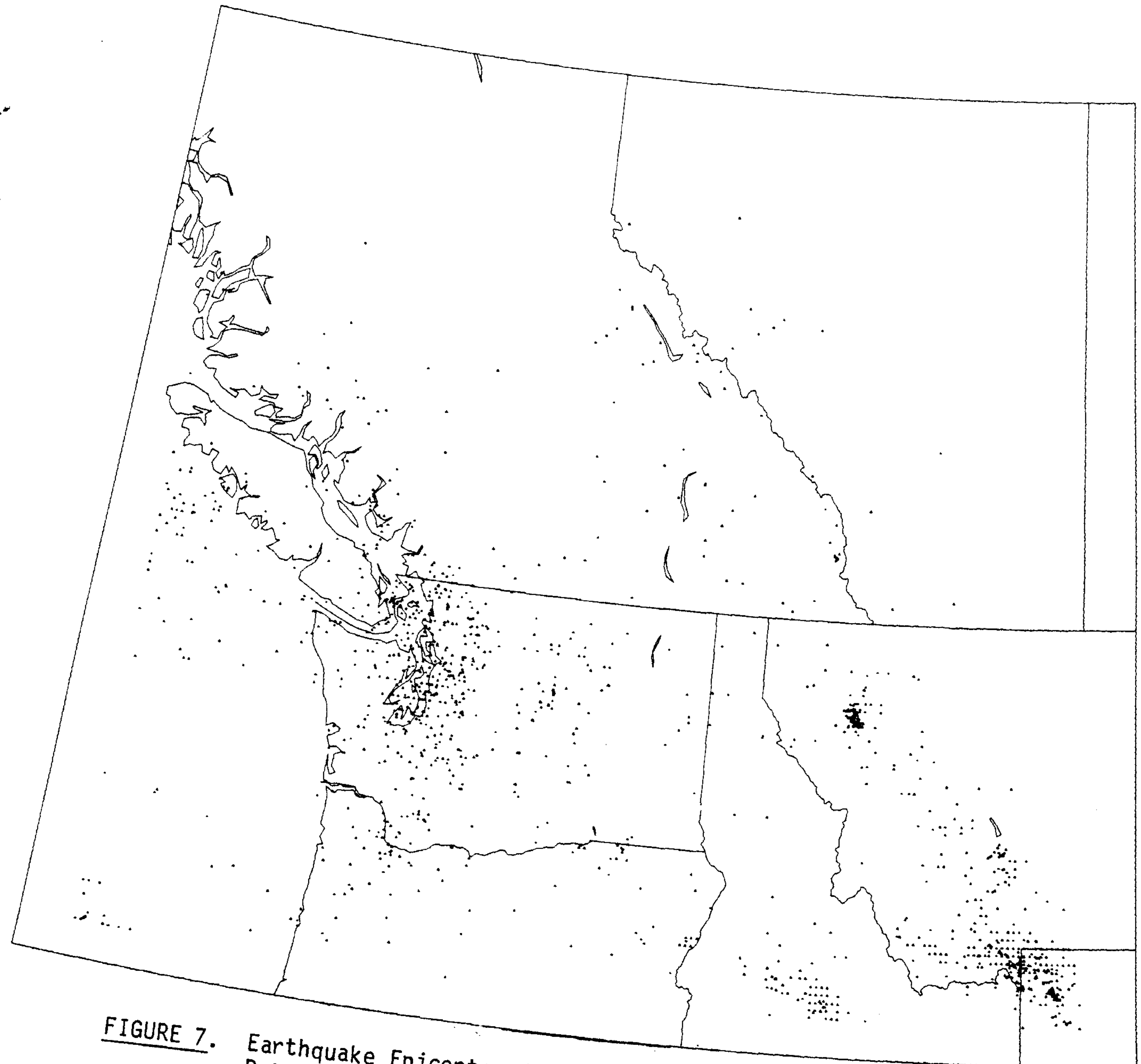


FIGURE 7. Earthquake Epicenter from the Woodward-Clyde Pacific Northwest Data File

possible duplicate events. The printout was used as a working base, and duplicate events were identified by consulting the Earthquake History of the United States (Coffman and Von Hake 1976) and the Woodward-Clyde catalog. In addition, minor corrections in the origin time, location, and intensity were made to some of the events, and felt area information from the Earthquake History of the United States was added. Figures 8 through 10 are histograms showing how the data are distributed in time and as a function of magnitude and intensity. The data seem to fall off below M=4.5 or I=5 in Figures 9 and 10, respectively, indicating a lack of completeness below these levels.

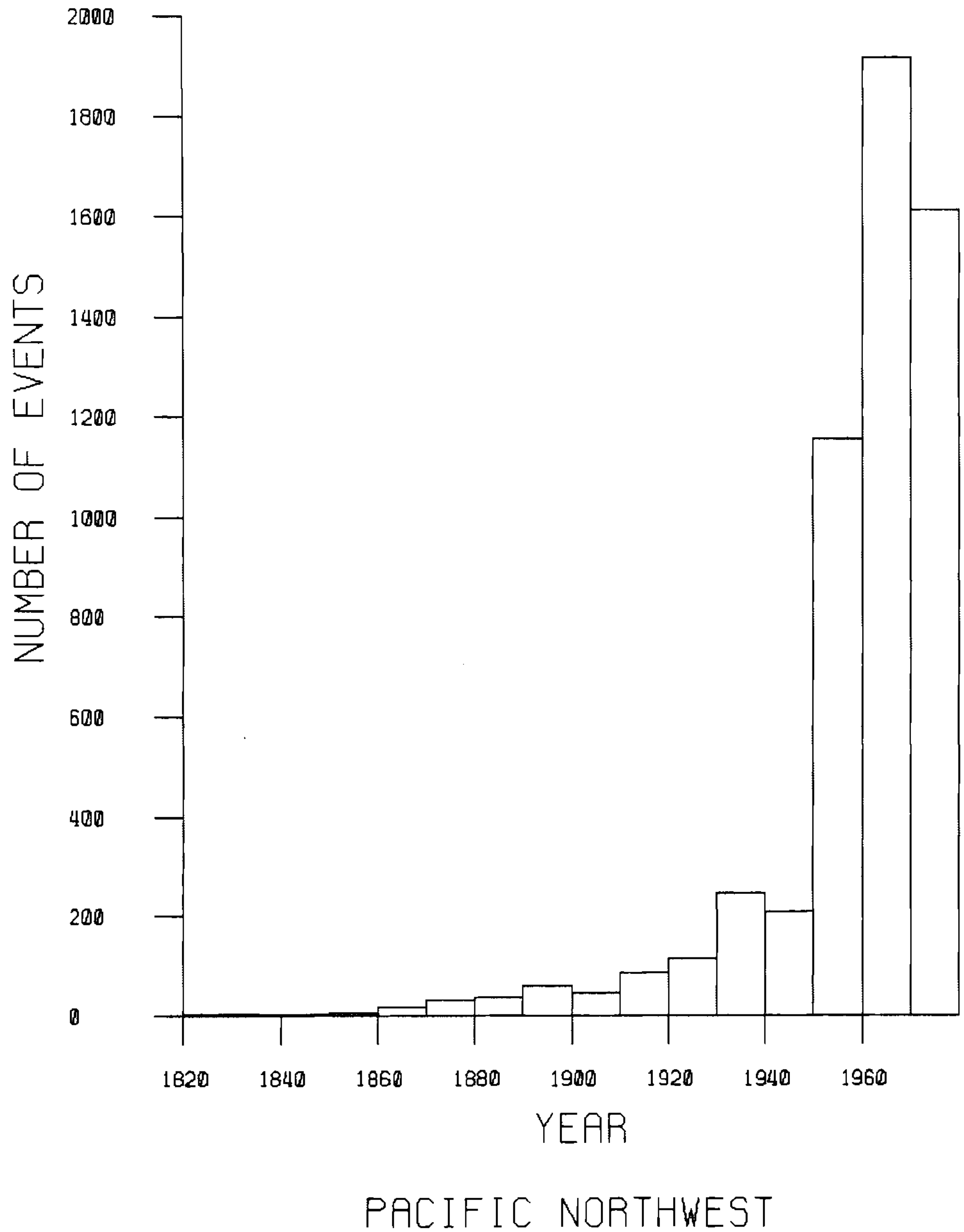


FIGURE 8. Histogram of Pacific Northwest Data by Year

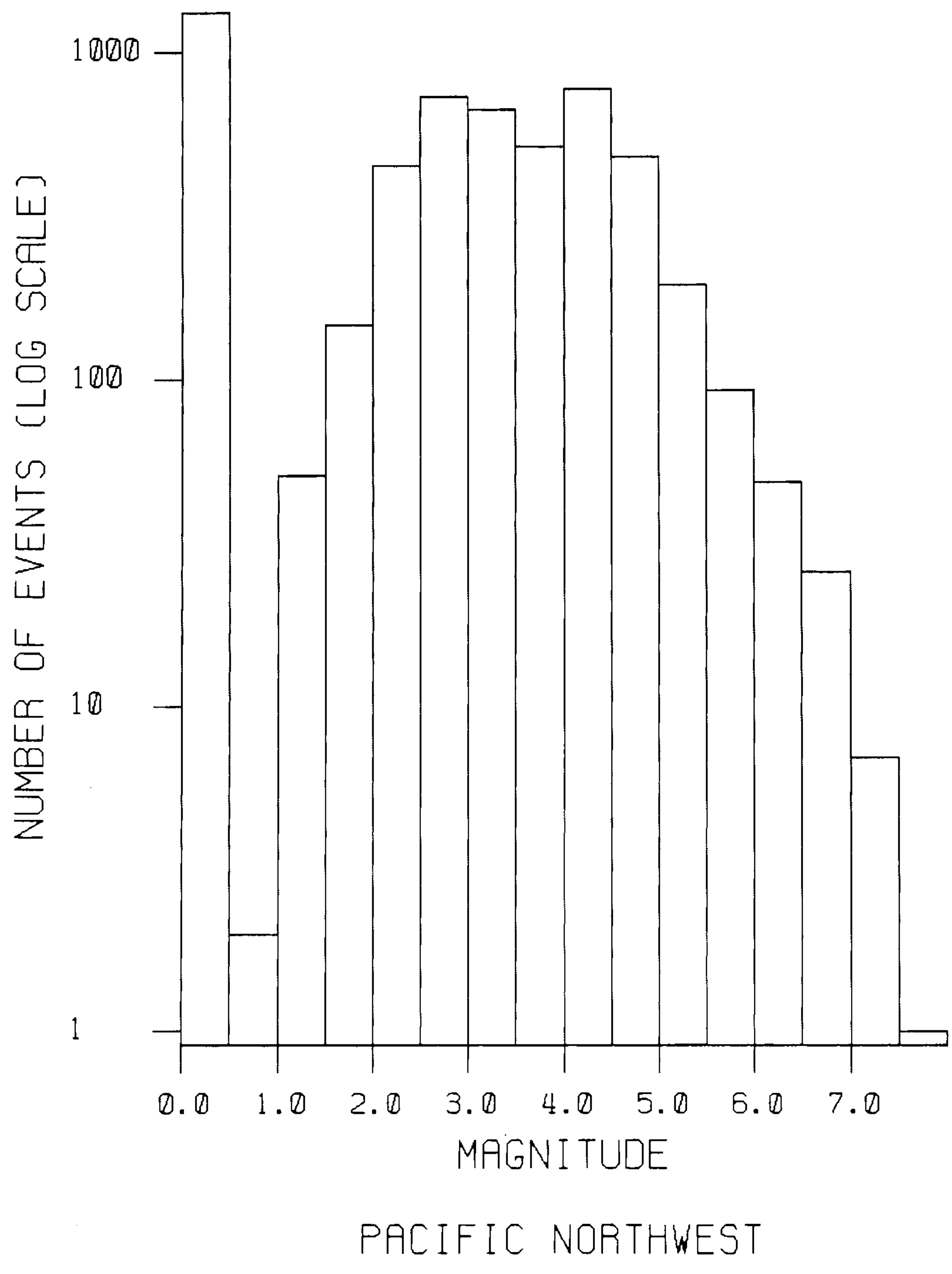


FIGURE 9. Histogram of Pacific Northwest Data by Magnitude

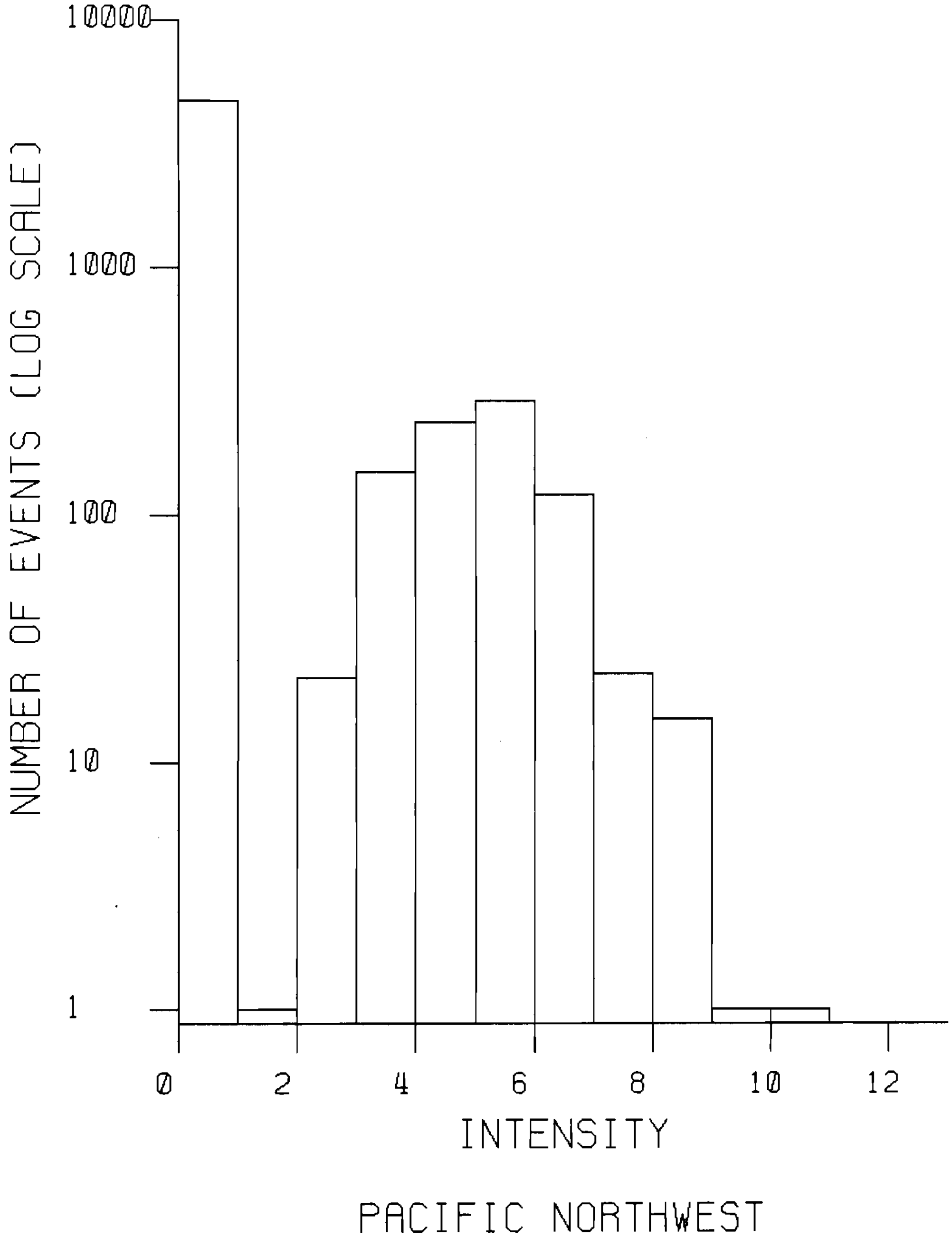


FIGURE 10. Histogram of Pacific Northwest Data by Intensity

DATA BASE STRUCTURE AND ANALYTICAL TECHNIQUES

This section describes the structure of the PNL Seismic Data Base and the analytical techniques available for use with the seismic data. Computer programs associated with each function are listed in parenthesis and are described further in the Appendix.

STRUCTURE (NEWQK1, QBIN, QFILEQ)

The structure of the PNL Seismic Data Base is shown in Figure 11. Data from each source are stored in permanent files that may be updated. The storage files contain 60 parameters describing each event (Table 2) and are in a rapid access format. Shorter working files containing 18 key parameters are formed from the storage files to decrease the handling time of the earthquake data. Table 3 shows the 18 key parameters for selected earthquakes. Each working file is then sorted with respect to time, location, and magnitude forming three ordered working files for each source. These sorted files may also be stored in a rapid access format.

Data catalogs appropriate to particular interests are formed from the sorted working files as follows:

a. Specified parameters are used to select data from each source.
b. Files of selected data are merged into one file and ordered chronologically.
c. Duplicate events are identified and deleted.

This procedure produces a complete and accurate catalog of events.

ANALYTICAL TECHNIQUES

The following techniques are available at PNL for analysis of seismic catalogs.

Editing (QEDIT, QEDIT1)

Data catalogs may be easily listed and/or edited. The listing in Table 3 was produced by the editing program QEDIT1. For editing, each line is

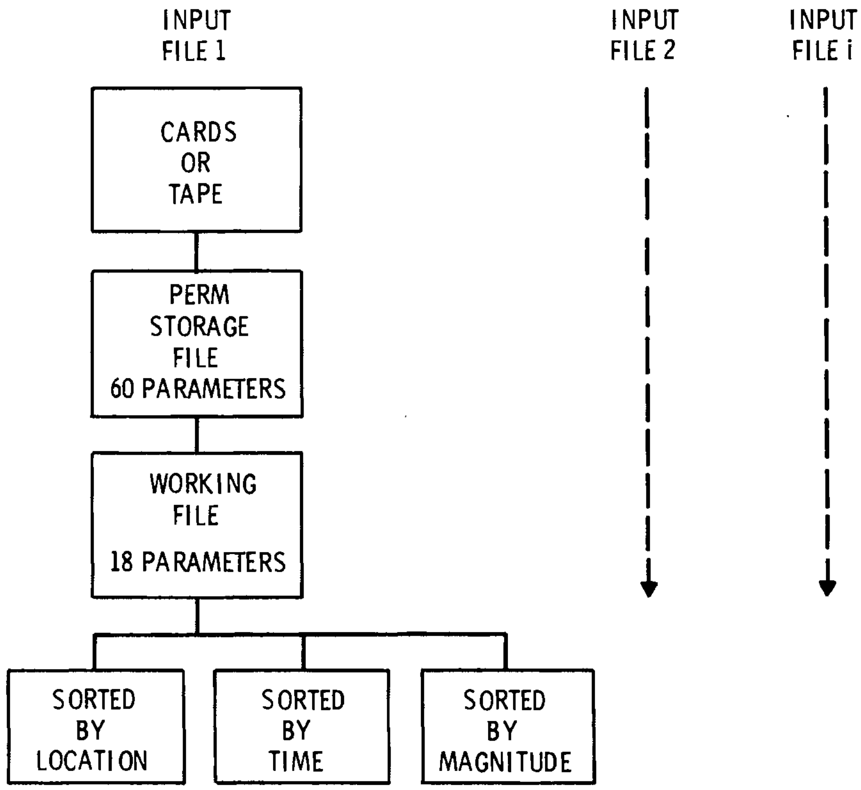


FIGURE 11. Structure of Data Catalog

TABLE 2. Typical Listing of a 60-Parameter Storage File

```
TIME= 19:39:42     DATE= 13-DEC-78


   IN THE FOLLOWING LISTING:
   (1) MSQ ARE 10 AND 1 DEGREE MARSDEN SQUARES.
   (2) ORIGIN TIME IS IN HOURS, MINUTES, AND SECONDS.POSITIVE IS GMT, NEGATIVE IS LOCAL TIME.
   (3) WEST LONGITUDES AND SOUTH LATITUDES ARE NEGATIVE.
   (4) DEPTH IS IN KILOMETERS, UNKNOWN DEPTH IS DESIGNATED BY -16.
   (5) MAG IS THE MAXIMUM OF THE FOUR PRECEDING VALUES (BODY WAVE, SURFACE WAVE,
       OTHER, AND LOCAL MAGNITUDES). MAGNITUDES ARE RICHTER SCALE.
   (6) INT IS MAXIMUM INTENSITY (MODIFIED MERCALLI SCALE, NEGATIVE IS ROSSI-FOREL).
   (7) AREA IS 10 LOG OF FELT AREA IN SQUARE KM.
   (8) EXP IS EXPLOSION CODE (E-EXPL.,P-PROB.OR POSS.EXPL.,
       R-ROCKBURST,C-COALBURST,M-METEOR,I-COLLAPSE,L-LIGHTS).
   (9) BAS IS DATA BASE CODE (N-NOAA,E-EWASH,W-WWASH,C-CANADA,P-PACIFIC NW WOODCLYDE,L-CALIFORNIA,G-GEOTECH
       M-MONTANA,O-CHINA

   OTHER PARAMETERS ARE:  [SOUR,QUAL,QAUT,DIAS,TSUN,SEIC,VOL,WAV,CULT,CX,KOC][ISO,MAGOS,MAGLS,INTNS,MSZH,ML,AREAS,LTVS,DMGS,LOC]
   [ISEQ,MSTN,GAP,STAT,FLIN,CODA,AREA][DEL,ERH,ERZ,ERM,RMS,LIV,DMG,MAGI,MAGK]


---------------------------------------------------------------------------------------------------
    MSQ           DATE        GMT         LONG-LAT       DEPTH  MB    MS  OTHER ML    MAG  INT AREA  EXP  BAS
---------------------------------------------------------------------------------------------------

  120   48      9  3 1905   54000.0  -118.300  34.000   0.0  0.00 0.00 0.00 0.00 0.00   -7    0          L
  [ 7   \      \ \ \ \ \ \ \ \ \ \ \ \] [    \     \     \   4\     \    \    \    \    \LOS ANGELES                   ]
  [     7      0      0     1     0     0     0] [   0.00    0.00    0.00    0.00    0.00     0.    0.00    0.00    0.00]

  121   72     12  3 1905  193000.0  -122.500  37.800   0.0  0.00 0.00 0.00 0.00 0.00   -5    0          L
  [ 7   \      \ \ \ \ \ \ \ \ \ \ \ \] [    \     \     \   4\     \    \    \    \    \SAN FRANCISCO BAY AREA        ]
  [     8      0      0     1     0     0     0] [   0.00    0.00    0.00    0.00    0.00     0.    0.00    0.00    0.00]

  120   58     12 23 1905  222300.0  -118.800  35.300   0.0  0.00 0.00 0.00 0.00 0.00   -8    0          L
  [ 7   \      \ \ \ \ \ \ \ \ \ \ \ \] [    \    7\     \   4\     \    \    \    \    \BAKERSFIELD, FELT LOS ANGELES TO VISALIA    ]
  [     2      0      0     1     0     0     0] [   0.00    0.00    0.00    0.00    0.00     0.    0.00    5.00    0.00]

  120   37      3  3 1906  202500.0  -117.000  33.000   0.0  0.00 0.00 0.00 0.00 0.00    5    0          L
  [ 7   \      \ \ \ \ \ \ \ \ \ \ \ \] [    \    7\     \   7\     \    \   7\    \    \SAN DIEGO COUNTY              ]
  [   975      0      0     1     0     0    13] [   0.00    0.00    0.00    0.00    0.00     0.    0.00    4.50    0.00]

  121   72      4 18 1906  131221.0  -122.500  37.700   0.0  0.00 0.00 0.00 8.25 8.25   11    0          L
  [100  \ 0    \ \ \ \ \ \ \ \ \ \ \ \] [    \   11\     \   3\     \  ML\  12\  14\  14\SAN FRANCISCO EARTHQUAKE (12 AND 100)     ]
  [     9      0      0     1     0     0    29] [   0.00    0.00    0.00    0.00    0.00   700.  524.00    0.00    0.00]

  121   72      4 18 1906  161400.0  -122.500  37.700   0.0  0.00 0.00 0.00 0.00 0.00   -5    0          L
  [ 7   \      \ \ \ \ \ \ \ \ \ \ \ \] [    \     \     \  12\     \    \    \    \    \SAN FRANCISCO AFTERSHOCK, BERKELEY AREA     ]
  [    10      0      0     1     0     3     0] [   0.00    0.00    0.00    0.00    0.00     0.    0.00    0.00    0.00]

  121   72      4 18 1906  161500.0  -122.500  37.700   0.0  0.00 0.00 0.00 0.00 0.00   -5    0          L
  [ 7   \      \ \ \ \ \ \ \ \ \ \ \ \] [    \     \     \  12\     \    \    \    \    \SAN FRANCISCO AFTERSHOCK, FELT TO SACRAMENTO]
  [    11      0      0     1     0     0     0] [   0.00    0.00    0.00    0.00    0.00     0.    0.00    0.00    0.00]
```

TABLE 3. Largest Earthquakes from the Pacific Northwest Data File

```
TIME= 14:26:07    DATE= 13-DEC-78

INPUT FILE=PNW.TIM
SORT PARAMETER=IORM
INTENSITY RANGE:    9   12     MAXIMUM MAGNITUDE RANGE:   7.00   9.00

    IN THE FOLLOWING LISTING:
    (1) MSQ ARE 10 AND 1 DEGREE MARSDEN SQUARES.
    (2) ORIGIN TIME IS IN HOURS, MINUTES, AND SECONDS.POSITIVE IS GMT, NEGATIVE IS LOCAL TIME.
    (3) WEST LONGITUDES AND SOUTH LATITUDES ARE NEGATIVE.
    (4) DEPTH IS IN KILOMETERS. UNKNOWN DEPTH IS DESIGNATED BY -16.
    (5) MAG IS THE MAXIMUM OF THE FOUR PRECEDING VALUES (BODY WAVE, SURFACE WAVE,
        OTHER, AND LOCAL MAGNITUDES). MAGNITUDES ARE RICHTER SCALE.
    (6) INT IS MAXIMUM INTENSITY (MODIFIED MERCALLI SCALE, NEGATIVE IS ROSSI-FOREL).
    (7) AREA IS 10 LOG OF FELT AREA IN SQUARE KM.
    (8) EXP IS EXPLOSION CODE (E-EXPL.,P-PROB,OR POSS,EXPL.,
        R-ROCKBURST,C-COALBURST,M-METEOR,I-COLLAPSE,L-LIGHTS).
    (9) BAS IS DATA BASE CODE (N-NOAA,E-EWASH,W-WWASH,C-CANADA,P-PACIFIC NW WOODCLYDE,L-CALIFORNIA,G-GEOTECH
        M-MONTANA,O-CHINA
```

MSQ		DATE	GMT	LONG-LAT		DEPTH	MB	MS	OTHER	ML	MAG	INT	AREA	EXP	BAS
157	91	12 14 1872	-214000.0	-121.000	49.167	0.0	0.00	0.00	7.50	0.00	7.50	9	62		P
157	96	12 6 1918	84105.0	-126.500	49.750	-16.0	0.00	0.00	7.00	7.00	7.00	5	0		N
157	15	1 31 1922	131722.0	-125.500	41.000	-16.0	0.00	0.00	7.30	0.00	7.30	6	0		N
194	11	5 26 1929	223954.0	-131.000	51.000	-16.0	0.00	0.00	7.00	0.00	7.00	7	0		N
157	95	6 23 1946	171319.0	-125.300	49.900	-16.0	0.00	0.00	7.30	7.30	7.30	8	0		N
157	72	4 13 1949	195543.0	-122.500	47.250	-16.0	0.00	0.00	7.00	7.10	7.10	8	58		N
156	41	8 18 1959	63715.0	-111.083	44.833	-16.0	0.00	0.00	7.10	7.10	7.10	10	62		N
194	11	6 24 1970	130908.0	-131.000	51.800	12.0	5.60	7.00	6.50	7.00	7.00	0	0		C

OUTPUT FILE, LARGE.OTN , HAS 8 EARTHQUAKES displayed on the terminal and editing commands are very similar to those of the RSX-11D system editor. Using the editor, an operator can change any parameters of an event, skip or delete any number of events, add information, insert events, and locate a desired event on a time sorted file.

Sorting (SORT)

Files may be arranged by time, location, or magnitude. The key used for time sorting is year, month, day, hour. For location the sort key consists of the 10 degree and 1 degree Marsden Square.[a] Maximum magnitude is used as the key for a magnitude sort.

Data Selection (ALLQK, SELECT)

Events can be selected from data files using the following parameters:

1. TIME (YEAR, MONTH, OR DAY)
2. LOCATION (LATITUDE-LONGITUDE, DISTANCE FROM A POINT)
3. MAGNITUDE (M_b, M_s, M_o, M_L, MAXIMUM MAGNITUDE, INTENSITY, MAXIMUM MAGNITUDE OR INTENSITY)
4. DEPTH
5. EARTHQUAKES ONLY
6. EXPLOSIONS ONLY
7. DECIMATION (EVERY N^{TH} EVENT CAN BE CHOSEN, WHERE N IS AN INTEGER)

Output from the selection programs is versatile. Files of selected events may be listed on the line printer, plotted as a histogram, or stored in a plot file compatible with the various graphic display facilities.

Merging of Files (PIP, AUTO, DOOP)

Independent files may be combined to form more complete catalogs using the process illustrated in Figure 12. The desired files are merged with PIP,

(a) Please refer to the NOAA publication, Earthquake Data File Summary, for an explanation of the numbering system for Marsden Squares. It is sufficient here to say that after this sort, all events within the same 10 degree square are together, and these events are further subdivided into 1 degree squares.

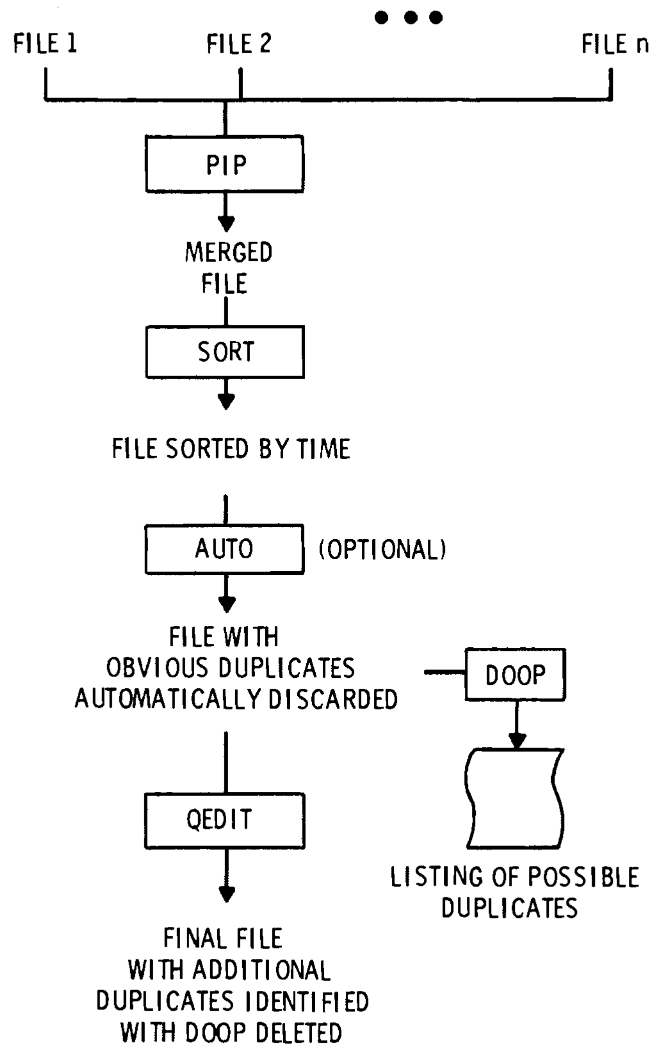


FIGURE 12. Flow Diagram for Seismic Merging Programs

an RSX-11D system program, and then sorted by time. AUTO can be used to discard obvious duplicates (within 1° in location and 5 sec in time, for example). Identification and deletion is automatic, although a printout is furnished to check that no mistakes have been made. In addition to saving time, this procedure is more accurate than a tedious search by hand and manual deletion using QEDIT, both of which leave many opportunities for human error. AUTO saves one event from each duplicate pair it identifies, along with the maximum intensity or magnitude if they differ.

Next, DOOP sifts through the millions of possible pairs of earthquakes from the remaining events in the file, printing out only the most probable duplicate pairs. Each pair of earthquakes (within 2 days of each other) in the file is examined and correlation values are assigned from the agreement in location, time, and magnitude intensity. The correlation scale ranges from 5 (exact match) to 1 (no way). The choice of parameter limits to assign to the five scale ranges is critical. The limiting values converged on (after five iterations) for the Pacific Northwest data are given in Table 4. If the geometric average of these three numbers is greater than a given cutoff value, the pair of events is printed out. This listing can then be studied, and duplicates can be deleted with QEDIT. Two or three iterations of DOOP and QEDIT is common, using a lower cutoff value for DOOP each time. Human judgment used with the listing from DOOP is vital for correct duplicate identification.

Histograms (HIST, HIST2, SELECT, ALLQK)

The number of events can be plotted as a function of the parameters listed in Figure 13. This technique is often used to display the logarithm of the number of earthquakes as a function of magnitude to yield a magnitude recurrence plot. Once computed, these histograms can be displayed using PNL's device independent graphics package. The histogram can be viewed on a CRT scope, plotted on the Gould electrostatic plotter or Calcomp plotter, or recorded on film with the Dicomed color image recorder without having to recompute a plot file. Two-dimensional histograms can be produced which plot

TABLE 4. Duplicate Identification Parameters for the Pacific Northwest

SIGMA SCALE	PARAMETERS	
5 - Exact Match	HRS -	Time difference between two events in hours
4 - Probable Match	DEG -	Distance between two events in degrees
3 - Possible	DELMAG -	Difference in magnitude ($M = 2/3\ I + 1$ used to convert intensity)
2 - Improbable		
1 - No Way		

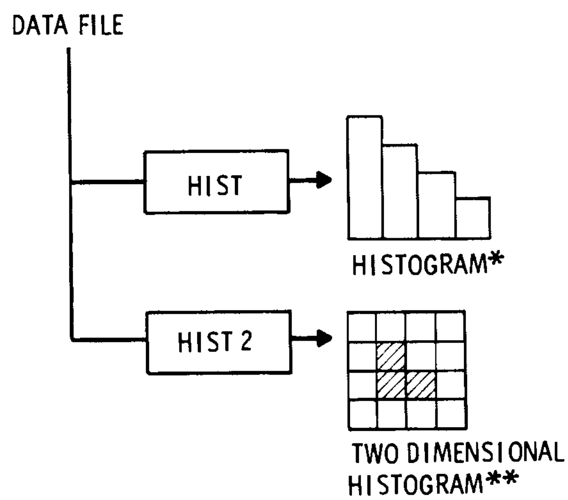
σ_T	Range
5	HRS = 0
4	$0 < \text{HRS} \le 0.1$
3	$0.1 < \text{HRS} \le 0.4$
2	$0.4 < \text{HRS} \le 25.0$
1	$25.0 < \text{HRS}$
ALSO:	
3.5	$0.9 < \text{HRS} < 1.1$
3.5	$6.9 < \text{HRS} < 7.1$
3.5	$7.9 < \text{HRS} < 8.1$
3	$11.9 < \text{HRS} < 12.1$
3	$23.0 < \text{HRS} < 25.0$
4	if the hour is unknown for one event
$\sigma_T=\sigma_T+1$	if year < 1900

σ_D	Range
5	DEG = 0
4	$0 < \text{DEG} \le 0.5$
3	$0.5 < \text{DEG} \le 1.25$
2	$1.25 < \text{DEG} \le 3.0$
1	$3.0 < \text{DEG}$

σ_M	Range
5	DELMAG = 0
4	$0 < \text{DELMAG} < 0.4$
3	$0.4 < \text{DELMAG} < 1.2$
2	$1.2 < \text{DELMAG} < 2.0$
1	$2.0 < \text{DELMAG}$
ALSO:	
99	if one magnitude is unknown
$\sigma_M=\sigma_M*(M-4)$	if > 5 where M is the average magnitude

TAKE GEOMETRIC MEAN TO GET FINAL SIGMA

$$\text{if } \sigma_M \ne 99,\ \sigma = \sqrt{\sigma_T\sigma_D\sigma_M}$$
$$\text{if } \sigma_M = 99,\ \sigma = \sqrt{\sigma_T\sigma_D}$$



*A HISTOGRAM OF THE NUMBER (OR LOG OF THE NUMBER) OF EVENTS AS A FUNCTION OF HOUR, MONTH, YEAR, DEPTH, INTENSITY, OR MAGNITUDE CAN BE PLOTTED.

**A TWO-DIMENSIONAL HISTOGRAM OF THE NUMBER (OR LOG NUMBER) OF EVENTS AS A FUNCTION OF TWO VARIABLES CAN BE PLOTTED. THE CHOICES ARE HOUR, MONTH, YEAR, DEPTH, INTENSITY, MAGNITUDE, LONGITUDE, LATITUDE, AND LOG FELT AREA.

FIGURE 13. Flow Diagram for Producing Histograms

the number of events as a function of two variables (these variables are also listed in Figure 13). The histograms can be output on the line printer or the color television monitor. Output of this type has been useful in determining how different magnitude scales relate to each other and how depth or magnitude distributions vary through time.

This type of histogram can also be used to effectively illustrate relationships between different earthquake parameters. Relationships between earthquake parameters have been shown to vary from one region to another because crustal structures vary. As an example, two-dimensional histograms plotting maximum magnitude versus felt area for Eastern and Western Washington are shown in Figures 14 and 15. These figures are indicative of the difference in attenuation constants for earthquakes in Eastern and Western Washington that was discussed by Malone and Bor (1979).

Epicenter Mapping Programs (MAPIN, MAP1, CLRQK, KEY)

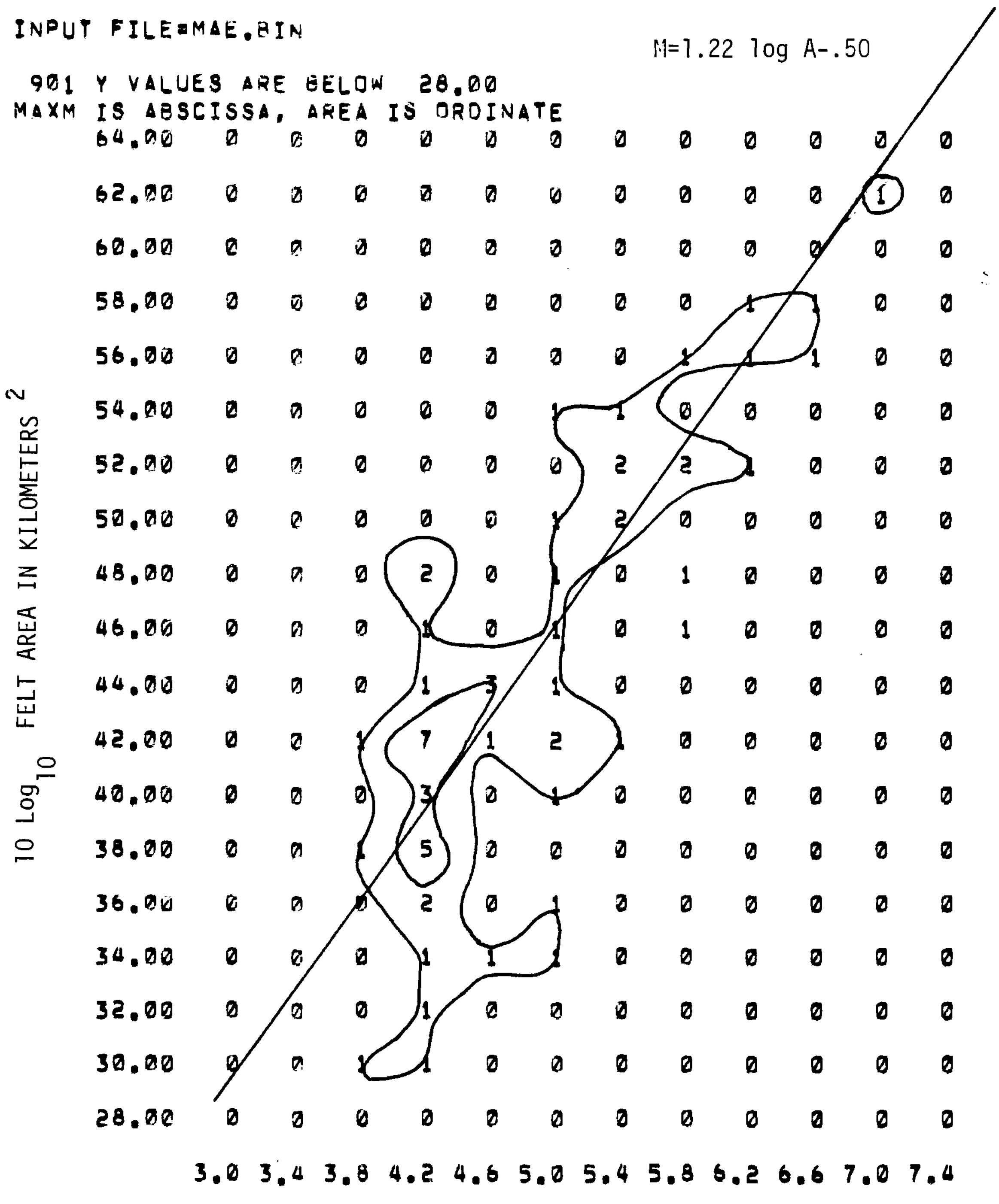
Earthquake epicenters can be plotted in conjunction with other desired geographic information (such as rivers, boundaries, faults) on various graphic devices. Epicenters can be plotted with symbol size a function of magnitude. In addition, magnitude and depth information can be displayed by plotting epicenters using varying size and color. Keys to the plots are also produced.

Hypocenter Mapping Programs (MAPIN, QK3D, CLR3D, MAP13D, QK3D1)

Three-dimensional hypocenter plots are produced by forming oblique projection stereo pairs from the data catalogs. The stereo pairs are produced in hard copy and can be viewed with a conventional stereo scope to show earthquake information in three dimensions. The high resolution and fine detail of the hard copy produce striking views of earthquake locations. Hypocenter locations may also be displayed on the memory refresh scope. This device offers the option of moving the observation point quickly and dynamically with a joy stick. With this technique, the viewing perspective can be maneuvered to search for hypocenter alignment along possible fault planes. Hypocenter information can be plotted on the real time color display monitor using a red-green stereo image. This plot appears three dimensional when viewed through red and green filtered glasses and has the advantage that many individuals

INPUT FILE=MAE.BIN

901 Y VALUES ARE BELOW 28.00
MAXM IS ABSCISSA, AREA IS ORDINATE



	3.Ø	3.4	3.8	4.2	4.6	5.Ø	5.4	5.8	6.2	6.6	7.Ø	7.4
64.ØØ	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
62.ØØ	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1	Ø
6Ø.ØØ	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
58.ØØ	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1	1	Ø	Ø
56.ØØ	Ø	Ø	Ø	Ø	Ø	Ø	Ø	1	1	1	Ø	Ø
54.ØØ	Ø	Ø	Ø	Ø	Ø	1	1	Ø	Ø	Ø	Ø	Ø
52.ØØ	Ø	Ø	Ø	Ø	Ø	Ø	2	2	1	Ø	Ø	Ø
5Ø.ØØ	Ø	Ø	Ø	Ø	Ø	1	2	Ø	Ø	Ø	Ø	Ø
48.ØØ	Ø	Ø	Ø	2	Ø	1	Ø	1	Ø	Ø	Ø	Ø
46.ØØ	Ø	Ø	Ø	1	Ø	1	Ø	1	Ø	Ø	Ø	Ø
44.ØØ	Ø	Ø	Ø	1	3	1	Ø	Ø	Ø	Ø	Ø	Ø
42.ØØ	Ø	Ø	1	7	1	2	1	Ø	Ø	Ø	Ø	Ø
4Ø.ØØ	Ø	Ø	Ø	3	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø
38.ØØ	Ø	Ø	1	5	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
36.ØØ	Ø	Ø	Ø	2	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø
34.ØØ	Ø	Ø	Ø	1	1	1	Ø	Ø	Ø	Ø	Ø	Ø
32.ØØ	Ø	Ø	Ø	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
3Ø.ØØ	Ø	Ø	1	1	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø
28.ØØ	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø	Ø

FIGURE 14. Two-Dimensional Histogram Plotting Maximum Magnitude Versus Felt Area for Pacific Northwest Data File East of 120°

INPUT FILE=MAW.BIN

M=1.47 log A-1.53

1815 Y VALUES ARE BELOW 28.00

MAXM IS ABSCISSA, AREA IS ORDINATE

10 LOG_{10} FELT AREA IN $KILOMETERS^2$	3.0	3.4	3.8	4.2	4.6	5.0	5.4	5.8	6.2	6.6	7.0	7.4
64.00	0	0	0	0	0	0	0	0	0	0	0	0
62.00	0	0	0	0	0	0	0	0	0	0	0	1
60.00	0	0	0	0	0	0	0	0	0	0	0	0
58.00	0	0	0	0	0	0	0	0	0	1	1	0
56.00	0	0	0	0	0	0	0	0	0	0	0	0
54.00	0	0	0	0	0	0	0	0	0	0	0	0
52.00	0	0	0	0	0	0	2	0	0	0	0	0
50.00	0	0	0	0	0	0	1	0	0	0	0	0
48.00	0	0	0	0	0	0	2	0	0	0	0	0
46.00	0	1	0	1	1	0	1	1	0	0	0	0
44.00	0	0	1	4	1	3	0	0	0	0	0	0
42.00	0	1	1	4	1	2	0	0	0	0	0	0
40.00	1	1	1	5	1	1	0	0	0	0	0	0
38.00	0	0	1	4	0	1	0	0	0	0	0	0
36.00	1	1	1	3	1	0	0	0	0	0	0	0
34.00	0	0	1	3	1	0	0	0	0	0	0	0
32.00	1	0	0	0	1	0	0	0	0	0	0	0
30.00	0	0	0	0	0	1	0	0	0	0	0	0
28.00	0	0	0	0	0	0	0	0	0	0	0	0

MAXIMUM MAGNITUDE

FIGURE 15. Two-Dimensional Histogram Plotting Maximum Magnitude Versus Felt Area for Pacific Northwest Data File West of 120°

can view the earthquake hypocenters in stereo simultaneously. The hypocenter mapping routines have been used to produce a set of 14 stereo views of the San Francisco Bay area for the United States Geological Survey to aid in studies of seismicity along the San Andreas Fault.

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APPENDIX

DESCRIPTION OF SEISMIC DATA FILES AND ASSOCIATED PROGRAMS

APPENDIX

DESCRIPTION OF SEISMIC DATA FILES AND ASSOCIATED PROGRAMS

FILES

Two types of files are used in the implementation of the seismic data base. These are rapid access (FILE-Q) files and binary (FILES-11) files. FILE-Q is the name given to a PNL software package where files can be read by random access at a speed approximately 10 times as fast as standard binary files. FILE-Q storage is used for the large source files which contain 60 parameters/quake and for certain working files (18 parameters/quake) that contain large numbers of events. FILE-Q short files (8 parameters/quake) are also used to store large plot files. Binary files are the standard storage files on the system.

PROGRAMS

The following is a brief description of the computer programs used with the seismic data. Because two distinct file structures were used, parallel sets of programs were written for editing files (QEDIT, QEDIT1) and for selecting data (ALLQK, SELECT). Parallel programs have also been developed for display of earthquakes on the memory refresh scope (QK3D, QK3D1). Programs operating on FILE-Q files are not as flexible as programs using binary files but have the advantage of handling large amounts of data quickly. Table 5[a] lists the programs and their appropriate file type.

Data Input Programs

Figure 16 is a flow chart for inputting raw seismic data into the data base.

NEWQK1 reads in data from cards or tape, translates it into a standard format and writes a storage file on a "File-Q" disk. There are 60 parameters in this file format (Table 6); some are byte variables (1/2 word of storage space), some are integer (1 word), and some are floating point (2 words).

(a) Tables and figures cited in this Appendix are continued from the main text.

TABLE 5. PNL Computer Programs and I/O Files

PROGRAM	INPUT FILE	OUTPUT
NEWQK1	CARDS or TAPE	FILE-Q
QBIN	FILE-Q	BINARY
SORT	BINARY	BINARY
QFILEQ	BINARY	FILE-Q
QEDIT	BINARY	BINARY L.P.
QEDIT 1	FILE-Q	FILE-Q L.P.
ALLQK	FILE-Q	FILE-Q BINARY L.P.
SELECT	BINARY	FILE-Q BINARY L.P.
HIST	BINARY	BINARY
HIST 2	BINARY	L.P.
AUTO	BINARY	BINARY L.P.
DOOP	BINARY	L.P.
MAPIN	BINARY	BINARY
MAP 1	BINARY	HARD COPY GRAPHICS
MAP13K	BINARY	COLOR SCOPE
QK3D	BINARY	SCOPE
QK3D1	FILE-Q	SCOPE

SOURCE DATA INPUT

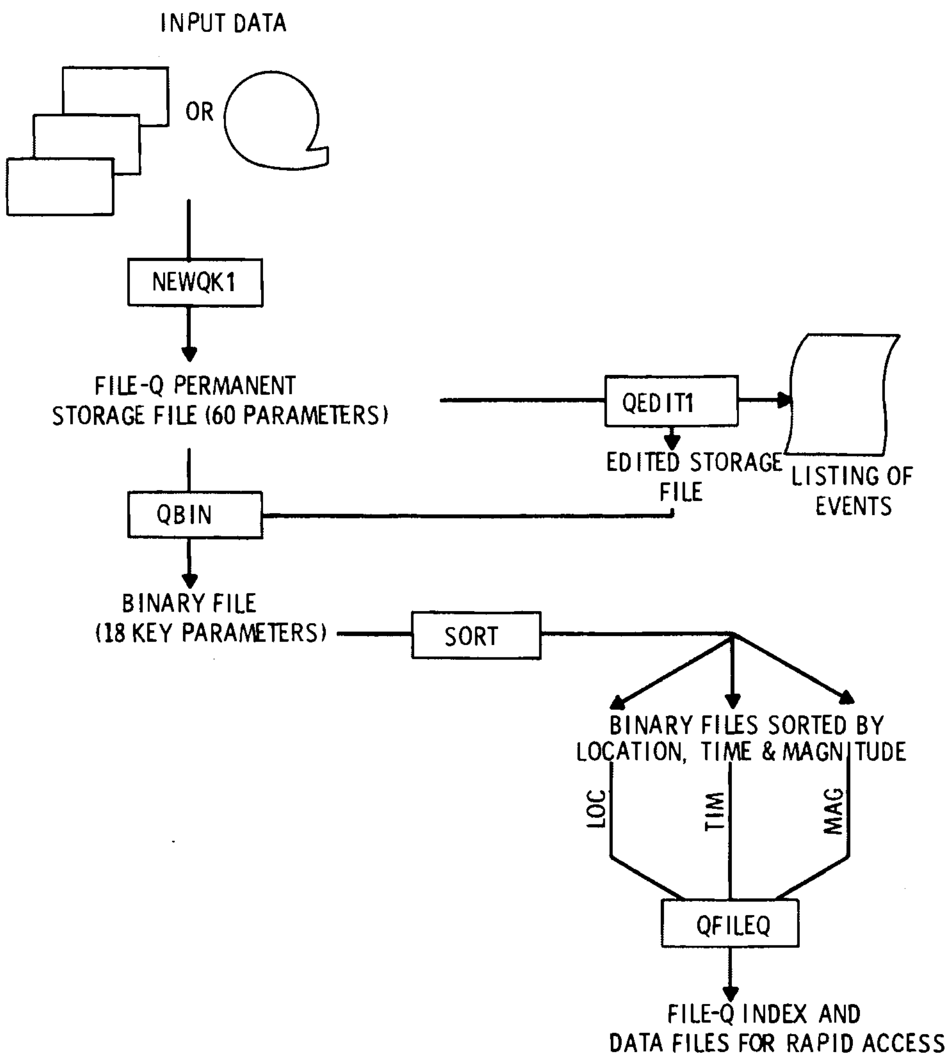


FIGURE 16. Flow Diagram for Seismic Input Programs

TABLE 6. Description of Earthquake Parameters

```
      BYTE MON,IDA,INTN,CERG,CEXP,CBAS,FILE(8)
      BYTE SOUR(6),QUAL(3),QAUT,DIAS,TSUN,SEIC,VOL,WAV
      BYTE CULT,CX,KDC,STAT,ISO(3),MAGOS(3),MAGLS(3),INTNS(3)
      BYTE MSZH,ML(2),AREA,AREAS(3),LIVS(3),DMGS(3),LOC(44)
      INTEGER DEL,GAP,ERH,ERZ,ERM,RMS,FLIN,CODA
      REAL LIV
      DIMENSION IDUM(3),IQK(85)
      DIMENSION IQUAKE(16),FNAM(2)
      COMMON M10,M1,MON,IDA,IYR,OT,GLON,GLAT,KD,MAGP,MAGS,
     1   MAGO,MAGL,MAG,INTN,CERG,CEXP,CBAS,SOUR,ISEQ,QUAL,
     2   QAUT,NSTN,DEL,GAP,ERH,ERZ,ERM,RMS,DIAS,TSUN,SEIC,
     3   VOL,WAV,CULT,CX,KDC,STAT,ISO,FLIN,MAGOS,MAGLS,
     4   INTNS,MSZH,ML,CODA,AREA,AREAS,LIV,DMG,LIVS,DMGS,
     5   PTA,PTB,LOC,MAGI,MAGK,IDUM
      EQUIVALENCE(M10,IQUAKE)
      EQUIVALENCE (M10,IQK)
      EQUIVALENCE (FILE,FNAM)
C
C
C     DEFINITION OF EARTHQUAKE VARIABLES
C     M10, M1:  MARSDEN 10 AND 1 DEGREE SQUARES
C     MON, IDA, IYR:  MONTH, DAY AND YEAR (- IS BC)
C     OT:  ORIGIN TIME IN HR-MN-SEC (- IS LOCAL TIME)
C     GLON, GLAT:  (- IS W. AND S.)
C     KD:  DEPTH TO TENTHS OF KM (-16.0 IS UNKNOWN)
C     MAGP, MAGS:  BODY AND SURFACE WAVE MAGNITUDES (IN 1/100 THS)
C     MAGO:  OTHER MAG.  (NUTTLI MAG FOR CANADA)
C     MAGL:  LOCAL MAG.
C     MAG:  MAXIMUM MAG. OF FOUR ABOVE
C     INTN:  MAXIMUM MM INTENSITY (- IS ROSSI-FOREL SCALE)
C     CERG:  10 LOG E 1/2 IN JOULES (E=4.8 + 1.5M JOULES)
C     CEXP:  E IS EXPLOS., P IS PROB.OR POSS. EXPLOS., R IS ROCKBURST,
C            C IS COAL BURST, M IS METEOR, I IS COLLAPSE, L IS LIGHTS SEEN
C     CBAS:  N IS NOAA, E IS EWN, W IS WWN, C IS CANADA, P IS PACIFIC
C             NW WOOD-CLYDE, L IS CALIFORNIA, G IS GEOTECH,
C             M IS MONTANA, Q IS CHINA.
C
C     THE ABOVE 18 VARIABLES ARE TRANSFERRED TO THE QUICK ACCESS FILES.
C
C     SOUR, ISEQ:  SOURCE OF HYPOCENTER LOCATION, SEQUENCE NUMBER
C     QUAL, QAUT:  QUALITY OF LOCATION, QUALITY OR AUTHORITY (NOAA)
C     NSTN, DEL, GAP:  NO. OF STNS USED, DISTANCE TO CLOSEST STN IN KM,
C                      LARGEST AZIMUTHUAL GAP IN KM
C     ERH, ERZ, ERM, RMS:  ERROR IN: EPICENTER (1/10 'S KM),
C                          FOCAL DEPTH (1/10 'S KM), MAG (1/100 TH'S),
C                          TIME (1/100'S SEC)
C     DIAS, TSUN, SEIC, VOL, WAV, CULT, CX, KDC:  NOAA CODES FOR:
C           DIASTROPHISM (F=FAULT, U=UPLIFT, D=BOTH)
C           TSUNAMI (T, Q=POSSIBLE TSUNAMI)
C           SEICHE (S, Q=POSSIBLE SEICHE)
C           VOLCANIC EVENT (V)
C           WAVES (T=TWAVE, A=ACOUSTIC, G=GRAV., V=BOTH A + G)
C           CULTURAL EFFECTS (C=CASULTIES, D=DAMAGE, F=FELT, H=HEARD)
C           SPECIAL EVENT FOR EXCHANGE (X)
C           DEPTH CONTROL (A=ASSIGNED, G=CONSTRAINED BY GEOPHYSICIST,
C              D=RESTRAINED DEPTH BASED ON PP, N=HELD AT 33 KM),
C     STAT:  1 = GOOD EVENT, 0 = BAD-DELETE
C     ISO:  ISOSEISMAL MAP EXISTS (SEE NOAA FOR CODE)
C     FLIN:  FLINN-ENGDAHL REGION NUMBER
C     MAGOS, MAGLS, INTNS:  SOURCES FOR MAGO, MAGL AND INTN
C     MSZH:  COMPONENT USED FOR MS (Z OR H)
C     ML:  LMAG CODE (ML=AMPL., MC=CODA)
C     CODA:  CODA LENGTH IN SECONDS
C     AREA, AREAS:  10 LOG OF FELT AREA IN SQUARE KILOMETERS AND SOURCE
C     LIV, DMG, LIVS, DMGS:  LIVES LOST, DAMAGE IN MILLIONS OF
C                            DOLLARS, AND RESPECTIVE SOURCES
C     PTA, PTB:  POINTERS
C     LOC:  LOCATION OF HIGHEST FELT INTENSITY AND OTHER COMMENTS
C     MAGI:  MAGNITUDE (IN 1/100 TH'S) FROM INTENSITY
C     MAGK:  MAGNITUDE (IN 1/100 TH'S) FROM KANAMORI (SEISMIC
C           MOMENT). LARGEST QUAKES ONLY (J.G.R. JULY 10,1977)
C     IDUM:  DUMMY VARIABLES
C
C
```

These files use 85 words of storage space for each earthquake. NEWQK1 is also used to update a storage file. A header block, which lists the history of updates for each seismic data file, is displayed before updating. Improved updates can be written over older updates. Table 7 lists the storage files at present.

QBIN converts a 60-parameter storage file on the FILE-Q disc to a corresponding 18 key parameter binary file on a FILES-11 disc. Files formed by QBIN use a storage space of 18 words/quake. This facilitates a saving of almost 5 to 1 in storage space and input/output transfer time. Table 3 (main text) showed the 18 key parameters for some chosen earthquakes. A useful feature recently added to the QBIN program affords the option of selecting events for conversion based on the number of stations used for epicenter location or on estimated error in depth determination.

SORT can arrange a binary earthquake file by time, location, or magnitude. It uses a FILE-Q "scratch" disc for quicker input/output and is based on a combination of a merge sort and the "quicksort" algorithm (Knuth 1978). Time required for sorting is roughly 20 sec/1000 quakes. The key used for the time sort is the year, month, day, and hour. For location, the sort key is the 10 degree and 1 degree Marsden Square. Maximum magnitude is used as the sort key for a magnitude sort.

QFILEQ constructs sorted rapid access FILE-Q files. Input to this program is 3 binary files, each consisting of the same data but sorted by time, location, and magnitude, respectively. Output is 3 corresponding FILE-Q data files and 3 FILE-Q index files. The data are indexed chronologically by year (1628 to 2000) by 10 degree Marsden Squares (1 to 936) for location, and by maximum magnitude (0 to 9.90) for magnitude. A printout lists the address and number of earthquakes for each index division. Presently, sorted rapid access FILE-Q files have been made for a World file (130,000 events), a California file (40,000 events), and a Pacific Northwest file (5,500 events).

Editing Programs

QEDIT and QEDIT1 can either list or edit a file. QEDIT operates on binary files while QEDIT1 is used with FILE-Q files. Using these editing programs,

TABLE 7. Storage Files

File-Q

Data Base	Latest Event	Events	File Name	File Size	Next Available Block
NOAA (NEIS)	Dec 1977	136547	NOAATAPE	50000.	45530.
W. Wash.	Dec 1977	2030	WWN1CARD	2000.	680.
Canada	Dec 1975	8165	CAN1TAPE	3000.	2730.
California	Dec 1974	39578	CAL1TAPE	14000.	13200.
Woodward-Clyde (Rev)	May 1975	2133	WOODCARD	1000.	720.
E. Wash	Dec 1974	1554	EWN1CARD	1000.	--
	Mar 1978	750	EWN2CARD	1500.	520.
Montana	Oct 1976	108	MONT	500.	40.
Oregon State (Couch)	Apr 1976	8808	OREGTAPE	3000.	2940.
Midwest (Nuttli)	Dec 1975	1115	MIDWEST		

Binary

Data	Events	File Name	File Size	Location
Merged Pacific Northwest Data	5548	PNW.TIM	434.	135°W-103°W 41°N-52°N
Edited Continental[a] United States Data	4487	CONTUS.TIM	351.	135°W-60°W 20°N-52°N
Edited World Data, M≥6, with Kanamori's Magnitude	6650	Q6.TIM	520.	World
Edited USSR-China Data with Additional Explosions Identified	20400	USSR.TIM	1594.	30°E-160°W 10°N-90°N

(a) Does not include midwest data base from Dr. O. W. Nuttli, St. Louis University, Missouri.

an operator can change any of the parameters of an event, skip any number of events, delete any number, add felt area information, insert an event, or locate a desired event (when used with a time sorted file). Again, commands are similar to the system editor; "top of file," "next line," and "exit" statements are included. The editing option has been frequently used in merging together various files (Figure 12).

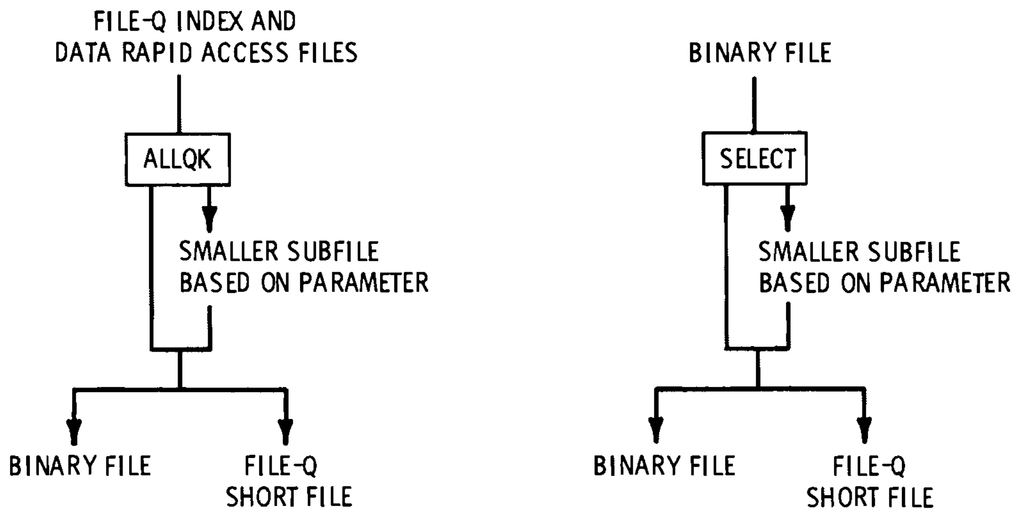
Selection Programs

Figure 17 shows the different selection programs. ALLQK and SELECT are very similar except that ALLQK operates on FILE-Q rapid access files (created with QFILEQ) whereas SELECT reads binary files. ALLQK is quicker for large files (and also has the advantage of plotting histograms during the selection process, see Figure 17), but SELECT is more commonly used for smaller working files. Both programs can select earthquakes based on the parameters listed in Figure 17. Outputs from the programs can be:

1. Binary file
2. File-Q short file - eight variables/quake
3. Listing
4. Histogram (ALLQK only)
5. Formatted "ANG" file - two variables/quake
6. Formatted "THR" file - three variables/quake
7. Formatted "MAG" file - three variables/quake
8. Binary plot file with symbol size a function of magnitude (SELECT only).

Histograms

The HIST program can plot the number of events as a function of the parameters listed in Figure 13. It has been used most often to display the logarithm of the number of earthquakes as a function of magnitude to yield the so-called magnitude recurrence plot. Once computed, these histograms can be displayed using PNL's device independent graphics package. The histogram can be viewed on a CRT scope, plotted on the Gould electrostatic plotter or Calcomp plotter, or recorded on film with the Dicomed color image recorder without having to recompute a plot file.



EVENTS CAN BE SELECTED ON THE FOLLOWING PARAMETERS:

(1) TIME (YEAR, MONTH, OR DAY)
(2) LOCATION (LATITUDE-LONGITUDE, DISTANCE FROM A POINT)
(3) MAGNITUDE (M_b, M_S, M_0, M_L, MAXIMUM MAGNITUDE, INTENSITY, MAXIMUM MAGNITUDE OR INTENSITY)
(4) EARTHQUAKES ONLY
(5) EXPLOSIONS ONLY
(6) DECIMATION (EVERY N^{TH} EVENT CAN BE CHOSEN, WHERE N IS AN INTEGER)
(7) DEPTH

FIGURE 17. Flow Diagram for Seismic Selection Programs

HIST2 can plot the number of events as a function of two variables (these variables are also listed in Figure 13). The histograms can be output on the line printer or the color television monitor (PDP 11/55 only). Output from HIST2 has been useful in determining how different magnitude scales relate to each other and how depth or magnitude distributions vary through time.

Merging Programs

The process of merging files and eliminating duplicates using programs AUTO and DOOP was adequately described in the text and will not be discussed here.

Epicenter Mapping Programs

Figure 18 shows the two-dimensional mapping programs. Files containing latitude and longitude information ("ANG" files) are formed with SELECT or ALLQK.

MAPIN converts the "ANG" file to a binary file which also has (plotting) symbol information on it.

MAP1 plots the earthquake file formed by MAPIN. The plot can be made on various devices using PNL's device independent graphics. The earthquake file can be plotted in conjunction with other desired files (such as rivers, boundaries, and faults) at a desired projection and scale. Plots can also be made with symbol size a function of magnitude.

CLRQK is used to show magnitude and depth information by plotting the epicenters in color on the real time color display monitor. The program is interactive; the pseudocolor scale or the location of the area of interest can be changed easily. CLRQK also uses binary files created with MAPIN.

KEY will make a plot file for the legend relating symbol size to magnitude.

Hypocenter Mapping Programs

Figure 19 shows how files created by SELECT and ALLQK can be used to construct three-dimensional hypocenter plots.

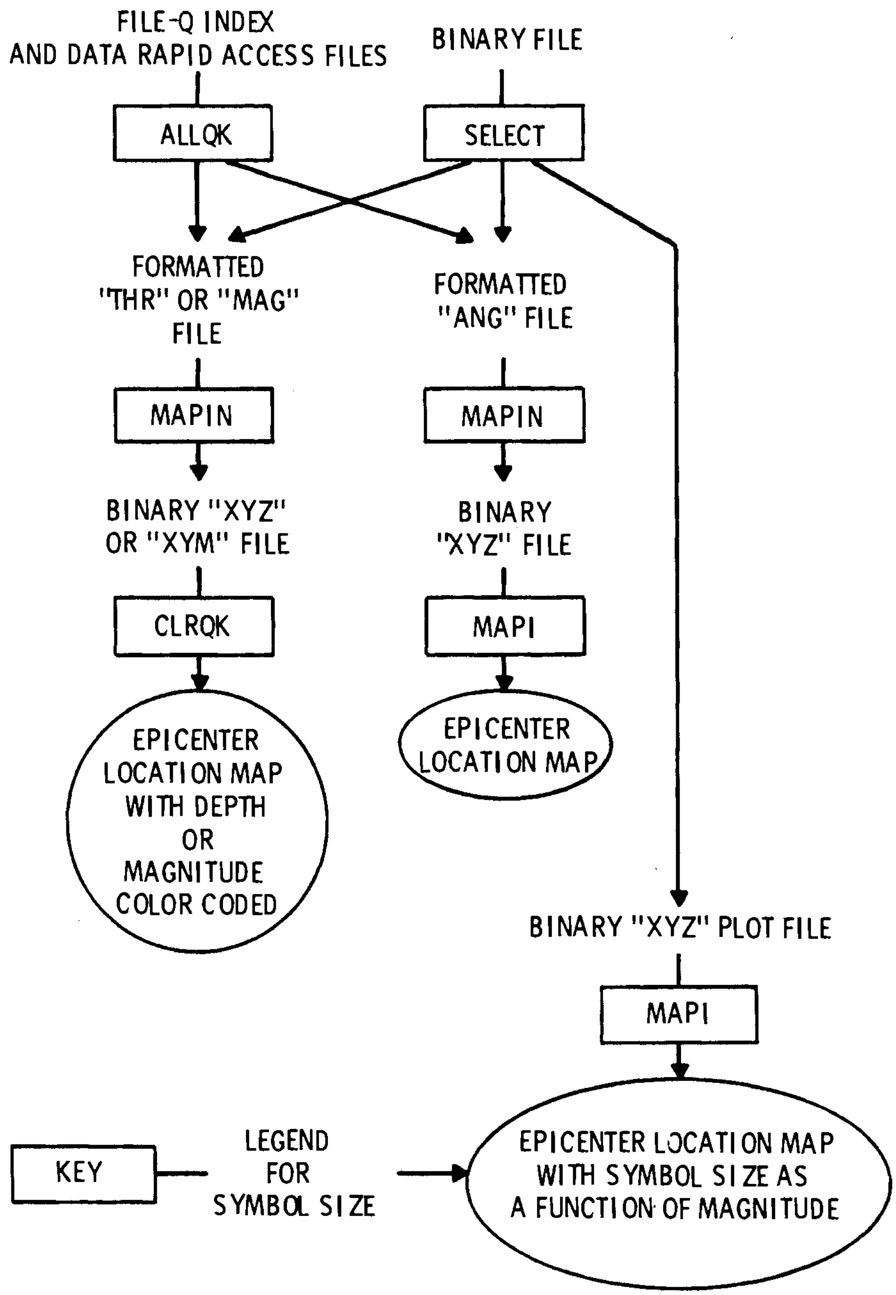


FIGURE 18. Flow Diagram for Seismic Mapping Programs

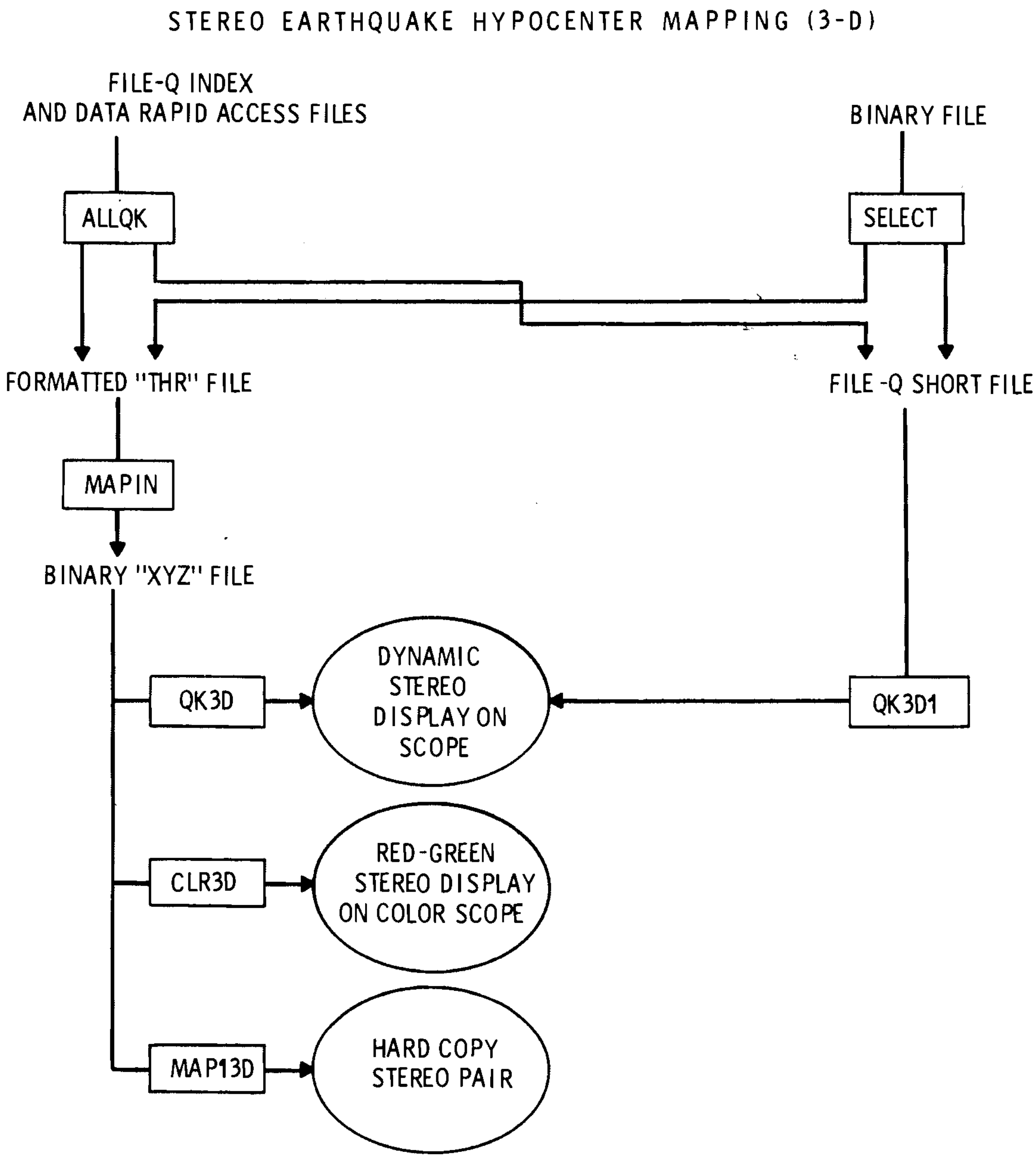


FIGURE 19. Flow Diagram for Seismic Stereo Programs

MAP13D produces an oblique perspective projection of the earthquake file along with other desired files to form one-half of a stereo pair. The viewing angle is varied slightly (roughly five degrees) for the other half of the pair. MAP13D is used to produce two hard copy stereo views.

QK3D produces a stereo projection, similar to MAP13D, that can be displayed on the memory refresh scope. This display has the option of moving the observation point quickly and dynamically by moving a joy stick.

CLR3D will plot a red-green stereo image on the real time color display monitor which appears three dimensional when viewed through red and green filtered glasses.

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FOREIGN

R. Riddihough
Victoria Geophysical Observatory
R.R. 7, Victoria, B.C.
CANADA

Gary Rogers
Victoria Geophysical Observatory
R.R. 7, Victoria, B.C.
CANADA

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