QUARTERLY NETWORK REPORT 85-B
on
Seismicity of Washington and Northern Oregon

April 1 through June 30, 1985

Geophysics Program
University of Washington
Seattle, Washington

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INTRODUCTION

This is the second quarterly report of 1985 from the University of Washington Geophysics Program covering seismicity of all of Washington and northern Oregon. These comprehensive quarterlies have been produced since the beginning of 1984. Prior to that we published quarterlies for western Washington in 1983 and for eastern Washington from 1975 to 1983. We have produced annual reports covering seismicity in western Washington since 1969 and in eastern Washington since 1975. In collaboration with the University of Washington the State Department of Natural Resources has published catalogs of earthquake activity in western Washington for the period 1970-1979. We will soon continue this series with annual catalogs for the whole state beginning with the year 1980.

This quarterly report discusses network operations, seismicity of the region, and unusual events or findings. This report is preliminary, and not a substitute for detailed technical reports, an annual catalog, or technical papers. In particular, event magnitudes are preliminary, and subject to revision. Some earthquake locations may be revised if new data become available, such as P and S readings from Canadian seismic stations. Findings mentioned in these quarterly reports should not be cited for publication. Figure 1 shows the major geographical features in the state of Washington and northern Oregon and the seismograph stations currently in operation. Figure 2 shows telemetry paths from seismograph stations to the University of Washington.

NETWORK OPERATIONS

Table 1 gives approximate periods of time when stations were inoperable. Data for Table 1 are compiled from weekly plots of network-wide teleseismic arrivals, plus records of maintenance and repair visits. Some stations which were inoperative during winter months spontaneously regained function when snow and ice melted in the spring.

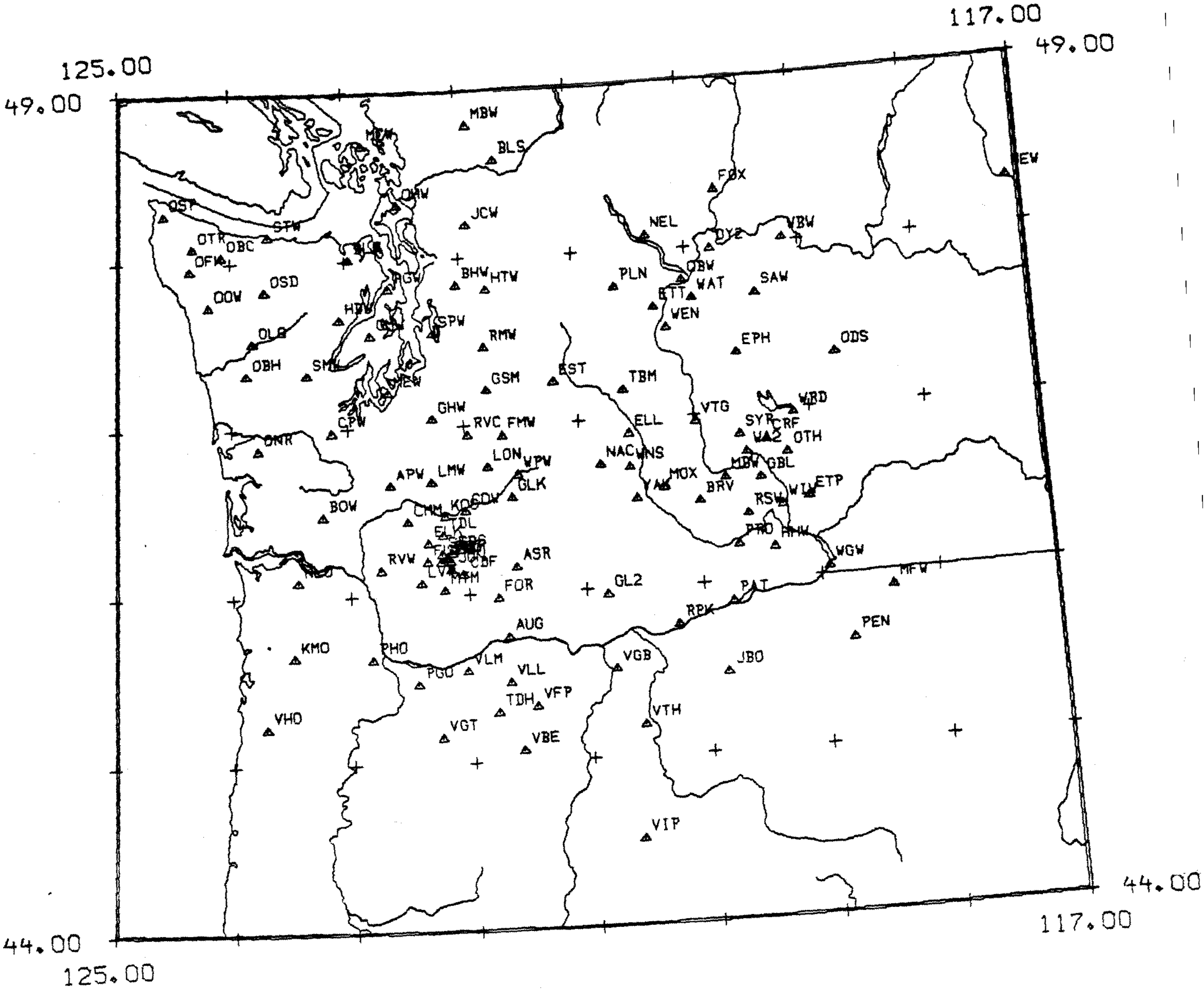


Figure 1. Seismograph stations operating during the second quarter 1985.

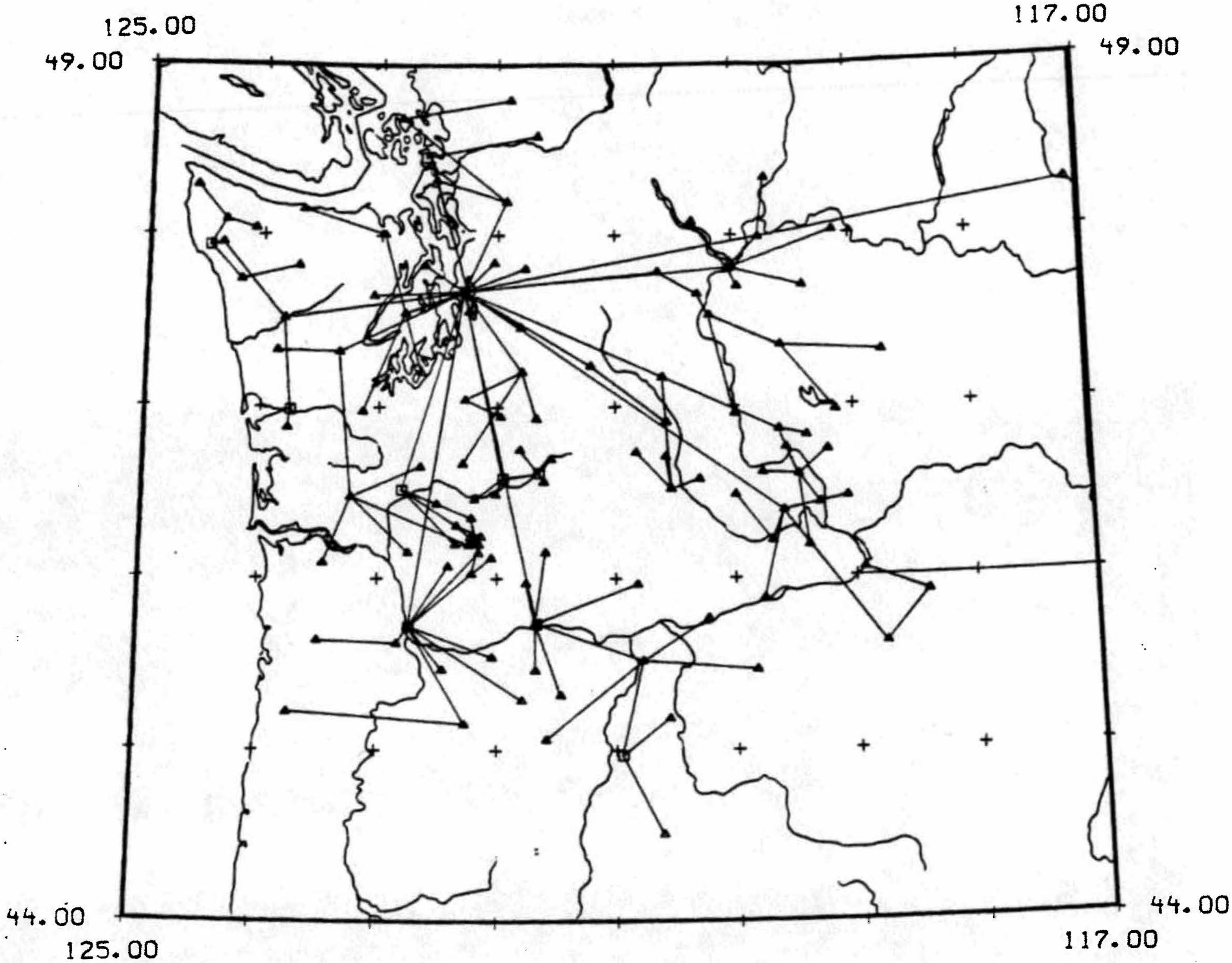


Figure 2. Seismograph stations and telemetry paths, second quarter 1985.

TABLE 1
Western Washington Network
Major station outages and changes, January 1, 1985 - June 30, 1985

Station	Outage Dates	Comments
	Western Washington	
APW	01/01/85-04/12/85	Repaired
HDW	01/01/85-06/30/85	Repaired
STW	01/01/85-03/16/85	Repaired
RVW	01/01/85-04/12/85	Repaired
PGW	00000000-04/12/85	Installed
MEW	00000000-03/05/85	Installed
BLS	01/01/85-03/20/85	Telemetry Path Available
	Olympic Peninsula	
ONR	03/03/85-03/16/85	Noisy
OSP	01/01/85-06/30/85	Intermittent
OBH	01/01/85-06/30/85	No Telemetry Path
	Mt. St Helens	
ASR	01/01/85-06/30/85	Intermittent Entire Time
ELK	5/24/85-6/3/85	Defective VCO
LVP	01/01/85-06/05/85	Repaired
MTM	01/01/85-06/30/85	Intermittent
SUG	01/01/85-06/30/85	Intermittent
RED	01/01/85-06/30/85	Needs Replacement
DIG	00000000-05/21/85	Installed
	Northern Oregon	
AUG	01/01/85-04/12/85	Repaired
KMO	01/01/85-04/09/85	Dead
NLO	1/20/85-6/30/85	Dead
VBE	3/27/85-06/30/85	Dead
VHO	01/01/85-06/30/85	No Telemetry Path
VGT	01/01/85-06/30/85	Will be replaced
VLL	01/01/85-04/12/85	Repaired
	Eastern Washington	
VTG	01/01/85-06/05/85	Intermittent, Repaired
MDW	01/01/85-06/30/85	Needs new Seismometer
OMK	06/22/85-06/30/85	Replaced by FOX
FOX	00000000-06/22/85	Installed
DYH	06/19/85-06/30/85	Replaced by DY2
DY2	00000000-06/19/85	Installed
FPW	05/30/85-06/30/85	Replaced by NEL
NEL	00000000-05/30/85	Installed

Western Washington and Northern Oregon

Stations in western Washington operated well during the second quarter. Repairs were made to several stations which had lost function since last field season. We are installing several stations in the Skagit Valley to replace stations lost in 1982. Signals will be telemetered to the U. W. via a Puget Power microwave link. Station BLS, installed in 1982, now has a telemetry route to the U. W., and has been providing data since March. The signal is quite spiky, however, and the station will probably be moved. Site permission is being sought for an additional station in the area. A calibrated three-component station, DIG, was installed in the crater of Mt. St. Helens in late May, during the early part of the recent eruption.

Stations in northern Oregon are in the process of being transferred to a microwave telemetry network operated by the Bonneville Power Authority (BPA). Some stations have been temporarily removed for refurbishing, others have been discontinued permanently and will be replaced by stations at other sites.

Eastern Washington

Signal quality at station VTG was improved after a repair visit. MDW apparently had a bad seismometer. Repair of a telemetry site at Chelan Butte improved the quality of FPW, GBW, and SAW. Several stations in eastern Washington were relocated to new sites in the same vicinities to prepare for switching to the BPA microwave network, which will allow us to discontinue several costly phone lines.

EARTHQUAKE DATA

There were 2145 events processed by the University of Washington digitally recording seismic network between April 1 and June 30, 1985. We determined locations for 1159 of these in Washington and Northern Oregon; 1085 were classified as earthquakes and 74 as known or suspected blasts. The remaining unlocatable events were regional events outside the U. W. network, or teleseisms. Helicorder records are scanned daily to ensure that significant events are not missed by the on-line digital system. Table 2 is the event catalog for this quarter. In the Mt. St. Helens area, only 241 events of $M_c \geqq 2.5$ have been included in the catalog; 600 smaller events have been omitted for brevity. Fig. 3 shows all earthquakes greater than magnitude 1.0. Fig. 4 shows blasts and probable blasts. Fig. 5 shows all earthquakes located in western Washington. Fig. 6 shows all earthquakes located in eastern Washington. Fig. 7 shows earthquakes located at Mount St. Helens.

Western Washington and Oregon

During the second quarter of 1985 1024 earthquakes were located between 44° 49° latitude and between 121° and 125° longitude. The greatest number of these events occurred at Mt. St. Helens, which erupted in May. Excluding Mt. St. Helens, 183 earthquakes occurred in western Washington. Eight had magnitudes larger than 3.0 and three of these were reported felt.

The Puget Lowland followed a typical pattern of diffuse seismicity with a few spots of slightly higher activity. One area of slightly elevated rate is in the eastern part of the Puget Basin, near Snohomish. Another such area is near Mt. Vernon, 75 km north of Seattle, where five tightly clustered events between M_c 1.7 and M_c 3.3 were located at depths of around 15 km between the 25th and 30th of April. The two largest events of this sequence; on April 26 (M_c = 3.0), and April 30 (M_c = 3.3); were felt. An event of M_c = 3.1 was felt in North Bend, east of Seattle in the Cascade Mountains, on June 16. Seventeen events of $M_c \geqq 1.0$ occurred during the quarter in northwestern Washington close to the Canadian border, near the town of Deming. This is a higher rate of seismicity than previously observed in the area. Event locations line up in a nearly north-south trend. Depths of these events are approximately 15 km.

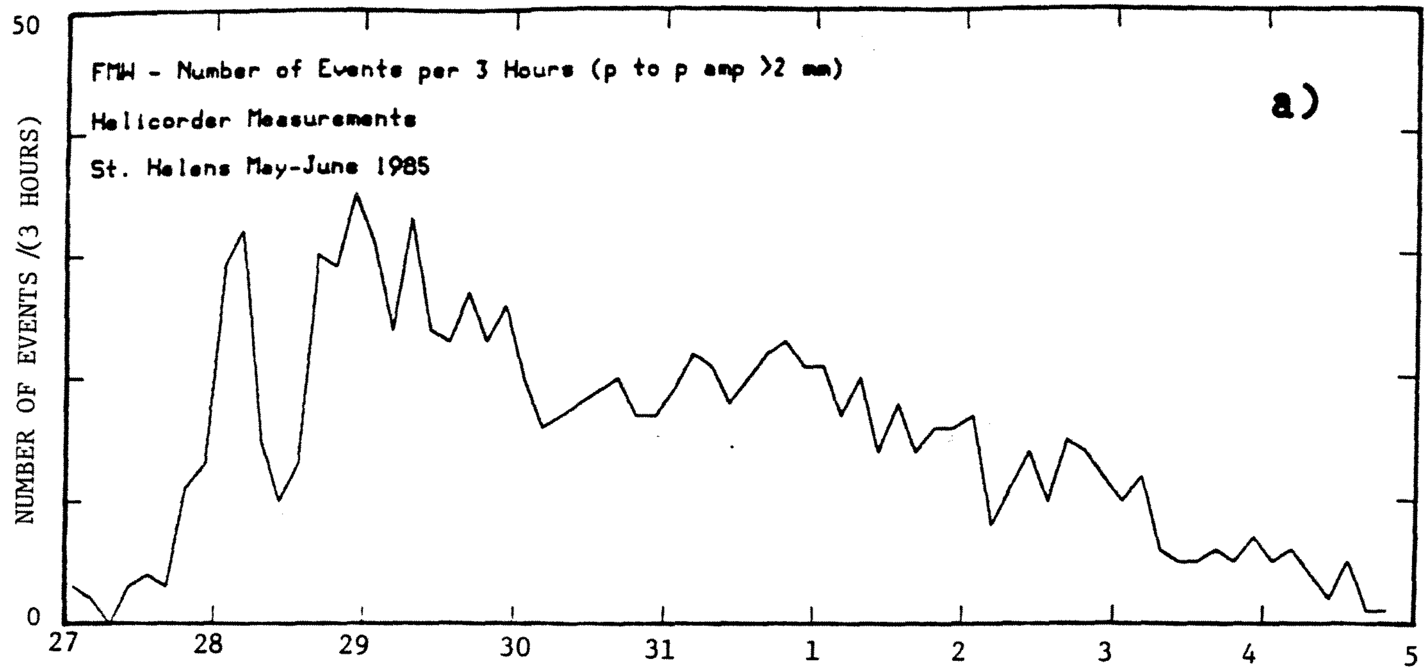
Eastern Washington and Oregon

A few events were located near the town of Vantage, on the Columbia River, the site of a spatial cluster of events since December 1984. A number of events were located near the southern end of Lake Chelan, as is usual for that area.

Mount St. Helens Area

Following a quiet April, Mt. St. Helens entered an eruptive phase in May 1985. The eruption produced a small extrusive lobe on the southeast side of the dome, and extensive deformation of the dome's south flank. The extrusion and deformation were preceded and accompanied by the most energetic earthquake sequence since the catastrophic eruption of May 18, 1980. The U. W. Seismic network located 841 events in the area shown in Fig. 7. Seismic activity reached a high level on May 23, 1985, and by May 29th, earthquakes of $M_c \geq 2.6$ were occurring every 5 to 10 minutes. Fig. 8 shows number of volcanic events and average event amplitude at station FMW from May 27 through June 5. Seismicity began to decline on June 2, and returned to background level by June 17. As with all eruptions at Mt. St. Helens, the number of events located is only a fraction of the total number of earthquakes recorded. From May 27th - June 6th (during the period of greatest seismic activity) only representative events were located, and the catalog is not complete. In fact the catalog has been edited so that it contains only located events of $M_c \geq 2.5$.

Several features of seismicity related to this eruption are noteworthy. Two separate families of "multiplets", where numerous events had nearly identical waveforms, have been identified, the first was between May 24 and May 26, and the second between May 27 and May 28. A second interesting observation is the division of events into two magnitude classes between May 29 and June 4, with larger events in the magnitude range 2.3 to 2.8, and smaller events with $1.0 \leq M_c \leq 1.8$. A distinct gap in the magnitude distribution appeared around M_c=2.0.



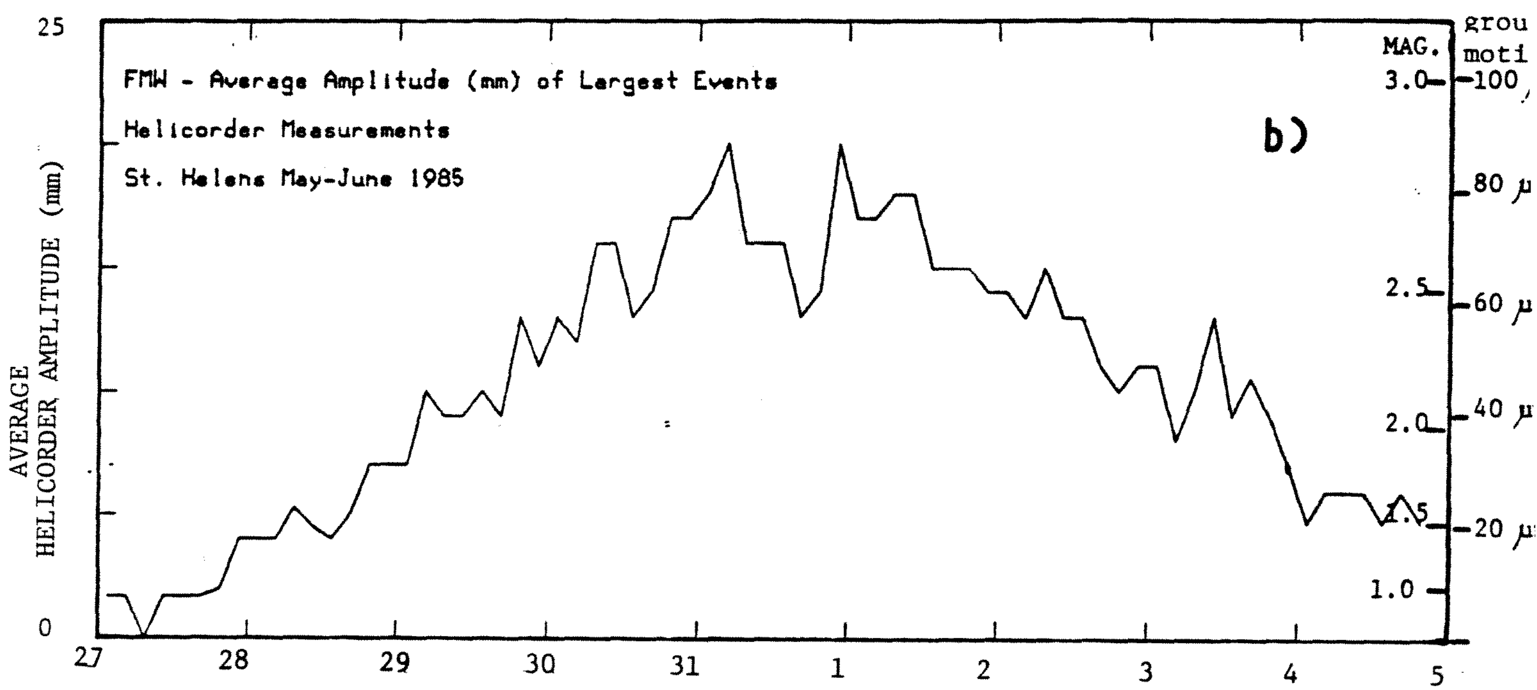


Figure 8a. Number of volcanic earthquakes at Mount St. Helens May 27-June 5, 1985. Plot shows number of events per 3 hour time interval exceeding 2mm peak-to-peak motion on FMW helicorder record (FMW is 100 km northeast of Mt. St. Helens).

Figure 8b. Size of largest volcanic earthquakes at Mt. St. Helens May 27-June 5, 1985. Left side shows peak-to-peak amplitude at FMW helicorder. Right side shows actual peak-to-peak ground motion at FMW in millimicrons, and approximate coda magnitude.

Hypocenters for this eruption had a bimodal depth distribution which appears to be related to both the magnitude bi-modality and the multiplet families. One group of events located in the upper .5 km, and a second group at a depth of about 1.2-1.5 km. The deeper events occurred between May 25 and June 4, and were generally larger than the shallow events. Both sequences of multiplets were in the deeper group of events.

Catalog

Table 2 is a catalog of located events between April 1, 1985 and June 30, 1985 in the state of Washington and northern Oregon. The columns are generally self-explanatory except that the following features should be noted:

a) The origin time listed is that calculated for the earthquake on the basis of multistation arrival times. It is given in Coordinated Universal Time (UTC), identical to Greenwich Civil Times; in hours:minutes (TIME); and seconds (SEC). To convert to Pacific Standard Time (PST) subtract eight hours, or to Pacific daylight time subtract seven hours.

b) The epicenter location is given in north latitude (LAT) and west longitude (LONG) in degrees and minutes.

c) In most cases the DEPTH, which is given in kilometers, is freely calculated by computer from the arrival-time data. In some instances, the depth must be fixed arbitrarily to obtain a convergent solution. Such depths are noted by an asterisk (*) in the column immediately following the depth. A $ or a # following the depth mean that the maximum number of iterations has been exceeded without meeting convergence tests and both the location and depth have been fixed.

d) MAG is an estimate of local Richter magnitude as calculated using the coda length-magnitude relationship determined for Washington. Where blank, data were insufficient or impossible to obtain for a reliable magnitude determination. Normally, the only earthquakes with undetermined magnitudes are very small ones. Magnitudes are preliminary only and may be revised as we improve our analysis procedure.

e) NS/NP is the number of station observations (NS) and the number of P and S phases (NP) used to calculate the earthquake location. A minimum of three stations and four phases are required. Generally the greater the number of observations used, the better the quality of the solution.

f) The root mean square residual (RMS) is taken about the mean of the station first-arrival residuals. It is only meaningful as a general statistical measure of the goodness of the solution when 5 or more well distributed stations are used in the solution. Good solutions are normally characterized by RMS values less than about 0.3 sec.

g) QUALITY of the hypocenter is a two letter code indicating the general reliability of the solution (A is best quality, D is worst). Similar quality factors are used by the USGS for events located with the computer program HYPO71. The first letter of the code is a measure of the hypocenter quality based on travel time residuals. For example A quality requires an RMS less than 0.15 sec. An RMS of 0.5 sec or more is D quality (estimates of the uncertainty in hypocenter location also affect this quality parameter). The second letter of the quality code depends on the spatial distribution of stations around the epicenter i.e. number of stations, their azimuthal distribution (GAP), and the minimum distance (DMIN) from the epicenter to a station. Quality A requires a solution with 8 or more phases, GAP ≤ 90° and DMIN ≤ (5 km or depth, whichever is greater). If the number of phases (see paragraph e above) is 5 or less or GAP > 180° or DMIN > 50 km the solution is assigned quality D. Note: GAP is the largest angular sector in azimuth (measured from the epicenter) containing no stations.

h) MODEL refers to the crustal velocity model used in the location