ANNUAL TECHNICAL REPORT: 1992

Name of Contractor:	**University of Washington**
Principal Investigators:	**S. D. Malone and A.I. Qamar** **Geophysics Program AK-50** **University of Washington** **Seattle, WA 98195**
Government Technical Officer:	**Dr. Elaine Padovani** **MS 905** **U.S. Geological Survey** **12201 Sunrise Valley Drive** **Reston, VA 22092**
Short Title:	**Seismic Monitoring of Volcanic and Subduction Processes in Washington and Oregon**
Program objective number:	**I-1**
Effective Date of J.O.A.:	**December 1, 1991**
J.O.A. Expiration Date:	**November 30, 1992**
Amount of J.O.A.:	**$222,000.**
Time Period Covered in Report:	**10/1/91 - 9/30/92**
Date Report Submitted:	**Dec. 28, 1992**

Supported by the
U.S. Geological Survey, Department of the Interior
under award number 1434-92-A-0963

ANNUAL TECHNICAL REPORT: 1992

Name of Contractor:	**University of Washington**
Principal Investigator:	**R. S. Crosson** **Geophysics Program AK-50** **University of Washington** **Seattle, WA 98195**
Government Technical Officer:	**Dr. Elaine Padovani** **MS 905** **U.S. Geological Survey** **12201 Sunrise Valley Drive** **Reston, VA 22092**
Short Title:	**Regional Seismic Monitoring in Western Washington**
Program objective number:	**I-1**
Effective Date of J.O.A.:	**December 1, 1991**
J.O.A. Expiration Date:	**November 30, 1992**
Amount of J.O.A.:	**$155,000.**
Time Period Covered in Report:	**10/1/91 - 9/30/92**
Date Report Submitted:	**Dec. 28, 1992**

Supported by the
U.S. Geological Survey, Department of the Interior
under award number 1434-92-A-0964

CONTENTS

TABLES

FIGURES

APPENDICES

Final Technical Report for USGS Joint Operating Agreements
1434-92-A0963
Seismic Monitoring of Volcanic and Subduction Processes in Washington and Oregon
and
1434-92-A0964
Regional Seismic Monitoring in Western Washington

Summary

This is the final technical report for USGS Joint Operating Agreements 1434-92-A0963 'Seismic Monitoring of Volcanic and Subduction Processes in Washington and Oregon'. and 1434-92-A0964 'Regional Seismic Monitoring in Western Washington' These two agreements cover network operations in western Washington and northern Oregon, routine data processing, and preparation of bulletins and reports. The objective of our work under these operating agreements is to gather data for use in evaluation of seismic and volcanic hazards in Washington and Oregon and to support research carried out under contract 14-08-0001-G1803 'Earthquake Hazard Investigations in the Pacific Northwest and Southern Alaska Using Network Data', as well as other projects. This report includes a review of station operations during the contract period, and an update on recent changes in our data acquisition and processing system.

Since 1984, we have issued quarterly bulletins for all of Washington and the northern part of Oregon. These include catalogs of earthquakes and blasts located in Washington and Northern Oregon, providing up-to-date coverage of seismic and volcanic activity. Appendix 1 contains quarterly bulletins covering this operating agreement period.

Operations

Twenty-eight stations covering much of western Washington are supported under JOA 1434-92-A0964, while fifty-two stations covering the Olympic Peninsula, volcanos in the central Cascades, and much of western Oregon are supported under JOA 1434-92-A0963. The locations of the stations are given in Tables 1 and 2, and shown in Fig. 1. All stations are north latitude and west longitude, and coordinates are given in degrees, minutes and seconds.

The University of Washington digitally records over 100 seismic stations in a triggered mode. Stations recorded include short and long period vertical components of WWSSN station LON and horizontal seismometers with Wood-Anderson-response at station SEA on the campus of the University of Washington.

Details of station operation from October 1991 through September 1992 are given in the quarterly reports in Appendix 1. Aside from station outages, normal maintenance includes a visit to each site at least once every two years to replace batteries and do preventive maintenance. In addition seismometers must be replaced every 4-6 years. More than 30 radio telemetry relay sites are also maintained independently of the seismograph stations.

Stations REM and YEL, located in the crater of Mt. St. Helens and operated by the USGS Cascades Volcano Observatory, were repaired in late 1991. In March, 1992, station APW (Alpha Peak, WA) was replaced by station LCW (Lucas Creek, WA) due to quarrying operations near APW. In June station WMO (Whale Mountain) was replaced by station BBO (Butler Butte, Oregon) at the request of the Forest service.

On June 28, under other contract support (USGS grant 1434-92-G-2195), we began testing a new type of seismograph station at the DWWSSN station site at Longmire in Mt. Rainier National Park. This new type of station includes a broadband 3-component Guralp seismometer and an on-site Reftek digital recorder that samples the signals at the site at 50 samples per second and can store up to 8 days of continuous data. Data of interest are retrieved by the WRSN via modem. We are developing software to streamline the processes of determining which events are of interest, retrieving the data, and integrating it into our analysis routines and trace data files. The Guralp seismometers have a flat frequency response to ground velocities from .01 to 25 Hz, and the Reftek provides a dynamic range of 96-120 dB (our analog telemetry has a dynamic range of 40-60 dB). Five of these stations will eventually be installed.

Stations supported under USGS JOAs A0963 and A0964, 1992

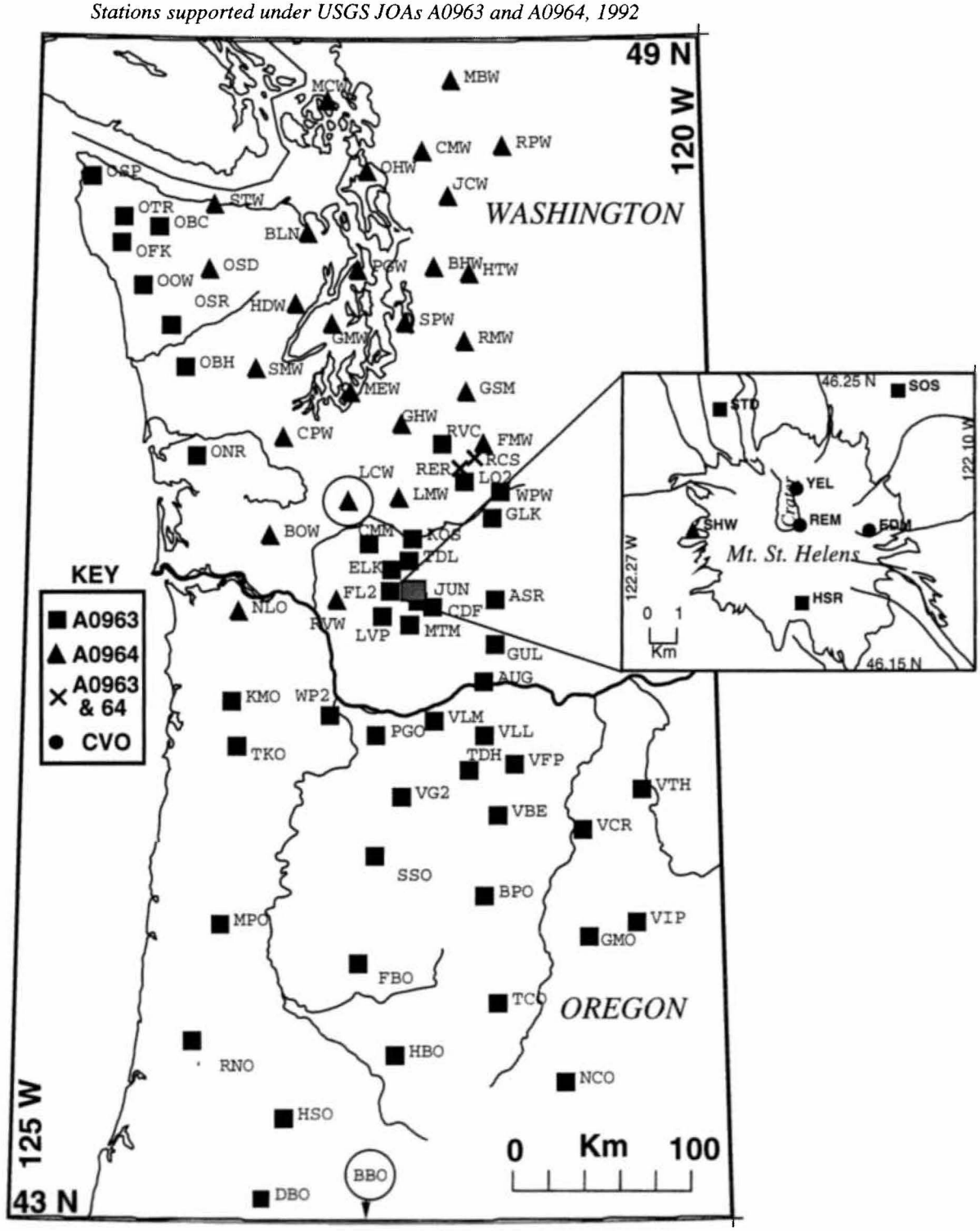

Figure 1. Map view of seismic stations supported under USGS JOAs 1434-92-A-0964 and 1434-92-A-0963 between Nov. 1, 1991 and Oct. 31, 1992. Fifty-two stations supported under JOA 1434-92-A-0963 (square symbols) cover the Olympic Peninsula and Cascade Mountains, including Mount St. Helens and other Cascade volcanos into central Oregon. One station, WMO (not shown), is located just south of the area shown. Twenty-eight stations supported under JOA 1434-92-A-0964 (triangular symbols) provide coverage of western Washington and the Mount Baker, Glacier Peak, and Mt. Rainier volcanos. Stations RCS and RER (operated jointly under both JOAs) are shown as "x" symbols.

TABLE 1

Stations supported under USGS Joint Operating Agreement 14-92-A-0964

NAME	LAT	LONG	ELEV(km)	LOCATION
BHW	47 50 12.6	122 01 55.8	0.198	Bald Hill
BLN	48 00 26.5	122 58 18.6	0.585	Blyn Mt.
BOW	46 28 30.0	123 13 41.0	0.870	Boistfort Mt.
CMW	48 25 25.3	122 07 08.4	1.190	Cultus Mtns.
CPW	46 58 25.8	123 08 10.8	0.792	Capitol Peak
FMW	46 56 29.6	121 40 11.3	1.859	Mt. Fremont
GHW	47 02 30.0	122 16 21.0	0.268	Garrison Hill
GMW	47 32 52.5	122 47 10.8	0.506	Gold Mt.
GSM	47 12 11.4	121 47 40.2	1.305	Grass Mt.
HDW	47 38 54.6	123 03 15.2	1.006	Hoodsport
HTW	47 48 14.2	121 46 03.5	0.833	Haystack Lookout
JCW	48 11 42.7	121 55 31.1	0.792	Jim Creek
LCW	46 40 14.4	122 42 02.8	0.396	Lucas Creek
LMW	46 40 04.8	122 17 28.8	1.195	Ladd Mt.
MBW	48 47 02.4	121 53 58.8	1.676	Mt. Baker
MCW	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MEW	47 12 07.0	122 38 45.0	0.097	McNeil Island
NLO	46 05 21.9	123 27 01.8	0.826	Nicolai Mt., Oregon
OHW	48 19 24.0	122 31 54.6	0.054	Oak Harbor
OSD	47 48 59.2	123 42 13.7	2.008	Olympics - Snow Dome
PGW	47 49 18.8	122 35 57.7	0.122	Port Gamble
RMW	47 27 35.0	121 48 19.2	1.024	Rattlesnake Mt. (West)
RPW	48 26 54.0	121 30 49.0	0.850	Rockport
RVW	46 08 53.2	122 44 32.1	0.460	Rose Valley
SHW	46 11 50.6	122 14 08.4	1.399	Mt. St. Helens
SMW	47 19 10.7	123 20 35.4	0.877	South Mtn.
SPW	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle
STW	48 09 02.9	123 40 13.1	0.308	Striped Peak

Data Processing

The seismographic network operated by the University of Washington consists of over one hundred short-period, vertical component, telemetered seismographic stations. The seismic recording system operates in an 'event triggered' mode, recording data at 100 samples per sec. per channel. The digital recording system is modeled after the CEDAR system originally developed at the California Institute of Technology by Carl Johnson. Arrival times, first motion polarities, signal durations, signal amplitudes, locations and focal mechanisms (when possible) are determined in postprocessing. Digital data are processed for all teleseisms, regional events, and all locatable local events. Each trace data file has an associated 'pickfile' which includes arrival times, polarities, coda lengths, and other data.

TABLE 2

Stations supported under USGS Joint Operating Agreement 1434-92-A0963

NAME	LAT	LONG	ELEV(km)	LOCATION
ASR	46 09 02.4	121 35 33.6	1.280	Mt. Adams - Stagman Ridge
AUG	45 44 10.0	121 40 50.0	0.865	Augspurger Mtn
BBO	42 53 12.6	122 40 46.6	1.671	Butler Butte, Oregon
BPO	44 39 06.9	121 41 19.2	1.957	Bald Peter, Oregon
CDF	46 06 58.2	122 02 51.0	0.780	Cedar Flats
CMM	46 26 07.0	122 30 21.0	0.620	Crazy Man Mt.
DBO	43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon
ELK	46 18 20.0	122 20 27.0	1.270	Elk Rock
FBO	44 18 35.6	122 34 40.2	1.080	Farmers Butte, Oregon
FL2	46 11 47.0	122 21 01.0	1.378	Flat Top 2
GLK	46 33 50.2	121 36 30.7	1.320	Glacier Lake
GMO	44 26 20.8	120 57 22.3	1.689	Grizzly Mountain, Oregon
GUL	45 55 27.0	121 35 44.0	1.189	Guler Mt.
HBO	43 50 39.5	122 19 11.9	1.615	Huckleberry Mt., Oregon
HSO	43 31 33.0	123 05 24.0	1.020	Harness Mountain, Oregon
HSR	46 10 22.2	122 10 58.2	1.774	South Ridge, Mt. St. Helens
JUN	46 08 48.0	122 09 10.8	1.049	June Lake
KMO	45 38 07.8	123 29 22.2	0.975	Kings Mt., Oregon
KOS	46 27 40.8	122 11 25.8	0.828	Kosmos
LO2	46 45 00.0	121 48 36.0	0.853	Longmire
LVP	46 04 06.0	122 24 30.0	1.170	Lakeview Peak
MPO	44 30 17.4	123 33 00.6	1.249	Mary's Peak, Oregon
MTM	46 01 31.8	122 12 42.0	1.121	Mt. Mitchell
NCO	43 42 14.4	121 08 18.0	1.908	Newberry Crater, Oregon
OBC	48 02 07.1	124 04 39.0	0.938	Olympics - Bonidu Creek
OBH	47 19 34.5	123 51 57.0	0.383	Olympics - Burnt Hill
OFK	47 57 00.0	124 21 28.1	0.134	Olympics - Forks
ONR	46 52 37.5	123 46 16.5	0.257	Olympics - North River
OOW	47 44 12.0	124 11 22.0	0.743	Octopus West
OSP	48 17 05.5	124 35 23.3	0.585	Olympics - Sooes Peak
OSR	47 30 20.3	123 57 42.0	0.815	Olympics Salmon Ridge
OTR	48 05 00.0	124 20 39.0	0.712	Olympics - Tyee Ridge
PGO	45 28 00.0	122 27 10.0	0.237	Gresham, Oregon
RNO	43 54 44.0	123 44 26.0	0.875	Roman Nose, Oregon
RVC	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek
SOS	46 14 38.5	122 08 12.0	1.270	Source of Smith Creek
SSO	44 51 21.6	122 27 37.8	1.242	Sweet Springs, Oregon
STD	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
TCO	44 06 21.0	121 36 01.0	1.975	Three Creek Meadows, Oregon.
TDH	45 17 23.4	121 47 25.2	1.541	Tom,Dick,Harry Mt., Oregon
TDL	46 21 03.0	122 12 57.0	1.400	Tradedollar Lake
TKO	45 22 16.7	123 27 14.0	1.024	Trask Mtn, Oregon
VBE	45 03 37.2	121 35 12.6	1.544	Beaver Butte, Oregon
VCR	44 58 58.2	120 59 17.4	1.015	Criterion Ridge, Oregon
VFP	45 19 05.0	121 27 54.3	1.716	Flag Point, Oregon
VG2	45 09 20.0	122 16 15.0	0.823	Goat Mt., Oregon
VIP	44 30 29.4	120 37 07.8	1.731	Ingram Pt., Oregon
VLL	45 27 48.0	121 40 45.0	1.195	Laurance Lk., Oregon
VLM	45 32 18.6	122 02 21.0	1.150	Little Larch, Oregon
VTH	45 10 52.2	120 33 40.8	0.773	The Trough, Oregon
WP2	45 33 56.0	122 47 12.0	0.338	West Portland, Oregon(replaces
WPW	46 41 53.4	121 32 48.0	1.250	White Pass

TABLE 3

Stations supported jointly by USGS JOAs 1434-92-A0963 and 1434-92-A0964

NAME	LAT	LONG	ELEV(km)	LOCATION
RER	46 49 09.2	121 50 27.3	1.756	Mt. Rainier, Emerald Ridge
RCS	46 52 15.6	121 43 52.0	2.877	Mt. Rainier, Camp Schurman

Outreach Activities

To improve communication with other networks and government agencies, we provide a public update service. Anyone on internet can access the most current information on seismic activity. The utility "finger quake@geophys.washington.edu" gives locations of significant Pacific Northwest earthquakes during the past several days, several of the the most recent WRSN locations, and the most recently received NEIS QED locations. The same service is available by dialing our main computer (206) 685-0889 and logging in as "quake" with password "quake".

We have also improved our ability to notify other agencies when a sizable earthquake occurs. Our computer continually monitors incoming signals, and automatically initiates alarms and alerts when an earthquake magnitude 2.8 or larger occurs within the network. These "alerts" take the form of either e-mail or FAXes to emergency agencies which give the automatically generated preliminary location and magnitude of the event. Meanwhile, the "alarms" notify the seismologist on duty who then reviews the event, determines the final location and magnitude, and e-mails or FAXes the final information to the agencies.

We currently exchange phase data with the Pacific Geoscience Centre semiannually. We have also initiated a phase and trace data exchange for the Corvallis, Oregon IRIS GSN station (COR). Data are exchanged on an event-by-event basis, and COR digital trace data is archived on tape along with the WRSN digital data, but in a separate file.

Publications

Publications wholly or partly supported under these operating agreements are listed in Appendix 2.

Acknowledgements

Seismic stations, telemetry links, and data acquisition equipment were maintained by Jim Ramey, Laurens Engel, and Patrick McChesney. Chris Jonientz-Trisler, Rick Benson, Ruth Ludwin, and Anthony Qamar provided information to the public and collected intensity reports for felt earthquakes; Chris left in June, 1992 for a new job at FEMA. Rick Benson provided routine data analysis and archiving of digital trace data, and wrote quarterly reports. Ruth Ludwin merged Canadian data into the pick files, wrote reports, provided data to investigators at other institutions, and handled miscellaneous administrative tasks. Anthony Qamar modified software, calibrated instruments, and provided quality control on phase picking.

APPENDIX 1

U. W. Seismic Network Quarterly Reports
91-D, 92-A, 92-B, 92-C

QUARTERLY NETWORK REPORT 91-D

on

Seismicity of Washington and Northern Oregon

October 1 through December 31, 1991

Geophysics Program

University of Washington

Seattle, Washington

This report is prepared as a preliminary description of the seismic activity in the state of Washington and northern Oregon. Information contained in this report should be considered preliminary, and not cited for publication. Seismic network operation in Washington and northern Oregon is supported by the following contracts:

U.S. Geological Survey
Joint Operating Agreement 14-08-0001-A0622
and
Joint Operating Agreement 14-08-0001-A0623

and

Westinghouse Hanford Company
Contract PMM-RJU-505

CONTENTS

FIGURES

TABLES

INTRODUCTION

This is the fourth quarterly report of 1991 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. Annual reports covering seismicity in Washington since 1969 are available from the U.W. Geophysics Program. In collaboration with the University of Washington, the State Department of Natural Resources (DNR) has published catalogs of earthquake activity in western Washington for the period 1970-1979. The DNR has published earthquake catalogs for the whole state for the period 1980-1986.

This quarterly report discusses network operations, seismicity of the region, and unusual events or findings. This report is 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. Fig. 1 is a map view of seismograph stations now in operation.

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. Fig. 1 shows a map view of stations operating during the quarter.

Relatively few changes were made to the network this quarter, with the only notable event being the repair of stations REM and YEL, both of which lie within the crater of Mt. St. Helens. These stations have been subject to long periods of inoperability since February of 1991 when they were repeatedly subject to steam explosion damage. Station REM was brought back online on November 6, and station YEL was repaired on November 15, but recorded only at the Cascades Volcano Observatory in Vancouver, Wa until the telemetry could be changed very early in January of 1992. Both sites were repaired by the staff at the Cascades Volcano Observatory.

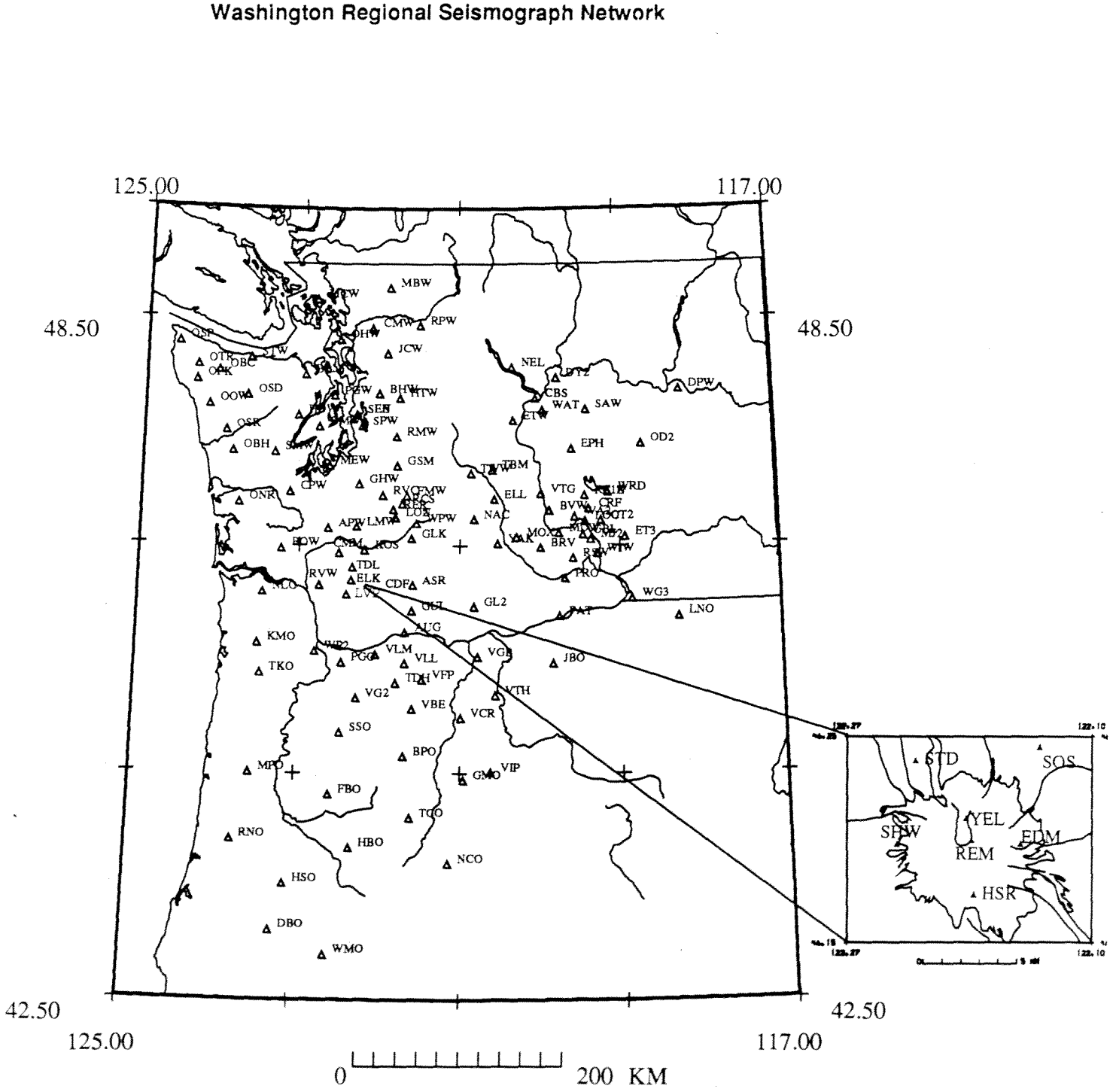

Figure 1: Stations operating at the end of the fourth quarter, 1991.

TABLE 1
Station Outages 4th quarter 1991

Station	Outage Dates	Comments
FL2	Beginning to Oct 10	Dead
GHW	Nov 10- ?	Dead
OBH	October 29-End	Dead
OD2	Oct 10-Oct 18	Dead
OSD	Dec 2-End	Intermittent;
PAT	Oct. 4-Oct 17	Bad cable
REM	Beginning to Nov 6	Dead
REM	Beginning to Nov 6	Dead
SMW	Nov 16-End	Died during storm
TWW	Oct. 4-Oct 17	Bad cable
VTG	Beginning to Oct 15	Solar panels stolen
WAT	Beginning - Nov 15	Dead;new seis and VCO
YEL	Whole Quarter	Dead; recieved at CVO from Nov 15

STATIONS USED FOR LOCATION OF EVENTS

Table 2 lists stations used in locating seismic events in Washington and Oregon. Stations marked by an asterisk (*) were supported by USGS joint operating agreement 14-08-0001-A0622. Stations marked by (%) were supported by USGS contract 14-08-0001-A0623. (+) indicates support under Westinghouse Hanford Company Contract PMM-RJU-505. All other stations were supported from other sources.

The first column in the table gives the 3-letter station designator. This is followed by a symbol designating the funding agency, station north latitude and west longitude (in degrees, minutes and seconds), station elevation in km, and comments indicating landmarks for which stations were named.

TABLE 2
Stations Operating at the End of the Third Quarter 1991

STA	F	LAT	LONG	EL	NAME
APW	*	46 39 06.0	122 38 51.0	0.457	Alpha Peak
ASR	%	46 09 02.4	121 35 33.6	1.280	Mt. Adams - Stagman Ridge
AUG	%	45 44 10.0	121 40 50.0	0.865	Augspurger Mtn
BHW	*	47 50 12.6	122 01 55.8	0.198	Bald Hill
BLN	*	48 00 26.5	122 58 18.6	0.585	Blyn Mt.
BOW	*	46 28 30.0	123 13 41.0	0.870	Boistfort Mt.
BPO	%	44 39 06.9	121 41 19.2	1.957	Bald Peter, Oregon
BRV	+	46 29 07.2	119 59 29.4	0.925	Black Rock Valley
BVW	+	46 48 37.8	119 52 54.1	0.707	Beverly
CBS	+	47 48 16.7	120 02 27.6	1.073	Chelan Butte, South
CDF	%	46 06 58.2	122 02 51.0	0.780	Cedar Flats
CMM	%	46 26 07.0	122 30 21.0	0.620	Crazy Man Mt.
CMW	*	48 25 25.3	122 07 08.4	1.190	Cultus Mtns.
COW	%	46 29 27.6	122 00 43.6	0.305	Cowlitz River
CPW	*	46 58 25.8	123 08 10.8	0.792	Capitol Peak
CRF	+	46 49 30.6	119 23 18.0	0.260	Corfu
DBO	%	43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon
DPW	+	47 52 14.3	118 12 10.2	0.892	Davenport
DY2	+	47 59 06.9	119 46 13.0	0.884	Dyer Hill 2
EDM		46 11 50.4	122 09 00.0	1.609	East Dome, Mt. St. Helens
ELK	%	46 18 20.0	122 20 27.0	1.270	Elk Rock
ELL	+	46 54 35.0	120 34 06.0	0.805	Ellensburg
EPH	+	47 21 12.8	119 35 46.2	0.628	Ephrata
ET3	+	46 34 37.0	118 56 11.0	0.305	Eltopia
ETW	+	47 36 16.2	120 19 51.6	1.475	Entiat
FBO	%	44 18 35.6	122 34 40.2	1.080	Farmers Butte, Oregon
FL2	%	46 11 47.0	122 21 01.0	1.378	Flat Top 2
FMW	*	46 55 54.0	121 40 19.2	1.890	Mt. Fremont

continued

STA	F	LAT	LONG	EL	NAME
GBL	+	46 35 51.6	119 27 35.4	0.330	Gable Mountain
GHW	*	47 02 30.0	122 16 21.0	0.268	Garrison Hill
GL2	+	45 57 35.0	120 49 22.5	1.000	Goldendale
GLK	%	46 33 50.2	121 36 30.7	1.320	Glacier Lake
GMO	%	44 26 20.8	120 57 22.3	1.689	Grizzly Mountain, Oregon
GMW	*	47 32 52.5	122 47 10.8	0.506	Gold Mt.
GRO	%	45 21 04.5	123 39 43.0	0.945	Grindstone Mt., Oregon
GSM	*	47 12 11.4	121 47 40.2	1.305	Grass Mt.
GUL	%	45 55 27.0	121 35 44.0	1.189	Guler Mt.
HBO	%	43 50 39.5	122 19 11.9	1.615	Huckleberry Mt., Oregon
HDW	*	47 38 54.6	123 03 15.2	1.006	Hoodsport
HSO	%	43 31 33.0	123 05 24.0	1.020	Harness Mountain, Oregon
HSR	%	46 10 22.2	122 10 58.2	1.774	South Ridge, Mt. St. Helens
HTW	*	47 48 12.5	121 46 08.6	0.829	Haystack Lookout
JBO	%	45 27 41.7	119 50 13.3	0.645	Jordan Butte, Oregon
JCW	*	48 11 36.6	121 55 46.2	0.616	Jim Creek
JUN	%	46 08 48.0	122 09 10.8	1.049	June Lake
KMO	%	45 38 07.8	123 29 22.2	0.975	Kings Mt., Oregon
KOS	%	46 27 40.8	122 11 25.8	0.828	Kosmos
LMW	*	46 40 04.8	122 17 28.8	1.195	Ladd Mt.
LNO	+	45 52 15.8	118 17 06.0	0.768	Lincton Mt., Oregon
LOC	+	46 43 04.8	119 25 54.6	0.201	Rohay Station
LO2		46 45 00.0	121 48 36.0	0.853	Longmire
LON		46 45 00.0	121 48 36.0	0.853	Longmire (DWWSSN)
LVP	%	46 04 06.0	122 24 30.0	1.170	Lakeview Peak
MBW	*	48 47 02.4	121 53 58.8	1.676	Mt. Baker
MCW	*	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MDW	+	46 36 48.0	119 45 39.0	0.330	Midway
MEW	*	47 12 07.0	122 38 45.0	0.097	McNeil Island
MJ2	+	46 33 28.0	119 21 50.0	0.150	Rockwell Station
MOX	+	46 34 38.0	120 17 35.0	0.540	Moxie City
MPO	%	44 30 17.4	123 33 00.6	1.249	Mary's Peak, Oregon
MTM	%	46 01 31.8	122 12 42.0	1.121	Mt. Mitchell
NAC	+	46 44 03.8	120 49 33.2	0.738	Naches
NCO	%	43 42 18.2	121 08 06.0	1.908	Newberry Crater, Oregon
NEL	+	48 04 41.8	120 20 17.7	1.490	Nelson Butte
NLO	*	46 05 18.0	123 27 00.0	0.900	Nicolai Mt., Oregon
OBC	%	48 02 07.1	124 04 39.0	0.938	Olympics - Bonidu Creek
OBH	%	47 19 34.5	123 51 57.0	0.383	Olympics - Burnt Hill
OD2	+	47 23 27.6	118 42 38.4	0.590	Odessa
OFK	%	47 57 00.0	124 21 28.1	0.134	Olympics - Forks
OHW	*	48 19 24.0	122 31 54.6	0.054	Oak Harbor
ONR	%	46 52 37.5	123 46 16.5	0.257	Olympics - North River
OOW	%	47 44 12.0	124 11 22.0	0.743	Octopus West
OSD	*	47 49 15.0	123 42 06.0	2.010	Olympics - Snow Dome
OSP	%	48 17 05.6	124 35 23.3	0.585	Olympics - Sooes Peak
OSR	%	47 30 20.3	123 57 42.0	0.815	Olympics Salmon Ridge
OT2	+	46 43 17.0	119 14 05.0	-	Othello
OTR	%	48 05 00.0	124 20 39.0	0.712	Olympics - Tyee Ridge
PAT	+	45 52 50.1	119 45 40.1	0.300	Paterson

continued

STA	F	LAT	LONG	EL	NAME
PGO	%	45 28 00.0	122 27 10.0	0.237	Gresham, Oregon
PGW	*	47 49 18.8	122 35 57.7	0.122	Port Gamble
PRO	+	46 12 45.6	119 41 09.0	0.552	Prosser
RC1		46 56 60.0	119 26 00.0	0.500	Royal City (3-component)
RCS		46 52 15.6	121 43 52.0	2.877	Mt. Rainier, Camp Schurman
REM		46 11 57.0	122 11 03.0	2.102	Rembrandt (Dome station)
RER		46 49 09.2	121 50 27.3	1.756	Mt. Rainier, Emerald Ridge
RMW	*	47 27 34.9	121 48 19.2	1.024	Rattlesnake Mt. (West)
RNO	%	43 54 44.0	123 44 26.0	0.875	Roman Nose, Oregon
RPW	*	48 26 54.0	121 30 49.0	0.850	Rockport
RSW	+	46 23 28.2	119 35 19.2	1.037	Rattlesnake Mt. (East)
RVC	%	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek
RVW	*	46 08 58.2	122 44 37.2	0.460	Rose Valley
SAW	+	47 42 06.0	119 24 03.6	0.690	St. Andrews
SEA		47 39 18.0	122 18 30.0	0.030	Seattle (Wood Anderson)
SEE		47 39 18.0	122 18 30.0	0.030	Seattle Pseudo-WA (E)
SEN		47 39 18.0	122 18 30.0	0.030	Seattle Pseudo-WA (N)
SHW	*	46 11 33.0	122 14 12.0	1.423	Mt. St. Helens
SMW	*	47 19 10.2	123 20 30.0	0.840	South Mt.
SOS	%	46 14 38.5	122 08 12.0	1.270	Source of Smith Creek
SPW	*	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle
SSO	%	44 51 21.6	122 27 37.8	1.242	Sweet Springs, Oregon
STD	%	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
STW	*	48 09 02.9	123 40 13.1	0.308	Striped Peak
TBM	+	47 10 10.1	120 35 54.0	1.064	Table Mt.
TCO	%	44 06 27.0	121 36 00.0	1.975	Three Creek Meadows, Oregon
TDH	%	45 17 23.4	121 47 25.2	1.541	Tom,Dick,Harry Mt., Oregon
TDL	%	46 21 03.0	122 12 57.0	1.400	Tradedollar Lake
TKO	%	45 22 16.7	123 27 14.0	1.024	Trask Mtn, Oregon
TWW	+	47 08 17.2	120 52 04.5	1.046	Teanaway
VBE	%	45 03 37.2	121 35 12.6	1.544	Beaver Butte, Oregon
VCR	%	44 58 58.2	120 59 17.3	1.015	Criterion Ridge, Oregon
VFP	%	45 19 05.0	121 27 54.3	1.716	Flag Point, Oregon
VG2	%	45 09 20.0	122 16 15.0	0.823	Goat Mt., Oregon
VGB	%	45 30 56.4	120 46 39.0	0.729	Gordon Butte, Oregon
VIP	%	44 30 29.4	120 37 07.8	1.731	Ingram Pt., Oregon
VLL	%	45 27 48.0	121 40 45.0	1.195	Laurance Lk., Oregon
VLM	%	45 32 18.6	122 02 21.0	1.150	Little Larch, Oregon
VTG	+	46 57 28.8	119 59 14.4	0.208	Vantage
VTH	%	45 10 52.2	120 33 40.8	0.773	The Trough, Oregon
WA2	+	46 45 24.2	119 33 45.5	0.230	Wahluke Slope
WAT	+	47 41 55.0	119 57 15.0	0.900	Waterville
WG3	+	46 01 43.0	118 51 24.0	0.480	Wallula Gap
WTW	+	46 25 48.8	119 17 13.4	0.130	Wooded Island
WMO	%	42 54 10.0	122 35 31.0	1.860	Whale Back Mt., Oregon
WP2	%	45 33 57.2	122 47 06.9	0.341	West Portland, Oregon
WPW	%	46 41 53.4	121 32 48.0	1.250	White Pass
WRD	+	46 58 11.4	119 08 36.0	0.378	Warden
YAK	+	46 31 15.8	120 31 45.2	0.619	Yakima
YEL		46 12 35.0	122 11 16.0	1.750	Yellow Rock, Mt. St. Helens

EARTHQUAKE DATA

There were 742 events processed by the University of Washington digital recording seismic network between October 1 and December 31, 1991. Locations were determined for 506 of these in Washington and Northern Oregon; 426 of these were classified as earthquakes and 80 as known or suspected blasts. The remaining 236 processed events include teleseisms (104 events), regional events outside the U. W. network (82), and unlocated events within the U. W. network. Unlocated events within the U.W. network include very small earthquakes and some known blasts. For example, only a few of the frequent mine blasts at Centralia are kept, and none are located.

Table 3 is the catalog of earthquakes and blasts located within the network for this quarter. Fig. 2 shows all earthquakes with magnitude greater than or equal to 0.0 ($M_c \geq 0.$) Fig. 3 shows blasts and probable blasts ($M_c \geq 0.$) Fig. 4 shows earthquakes located at Mt. Rainier ($M_c \geq 0$). Fig. 5 shows earthquakes located at Mt. St. Helens ($M_c \geq 0$).

Western Washington and Oregon

During the fourth quarter of 1991, 372 earthquakes were located between 42.5° and 49.5° north latitude and between 121° and 125° west longitude. Most of these occurred at depths less than 30 km with, as usual, a small number of earthquakes in the Puget Sound lowland and near the Olympic Peninsula at depths greater than 30 km.

During the fourth quarter, there were four earthquakes reported felt in western Washington and Oregon. Three of them occurred 23 km West- Northwest of Portland, Oregon. (Note: two similar events were reported felt and occurred in the same area last quarter.) The first two occurred on October 18 UTC, and had M_c = 3.1 and M_c = 2.8, with depths of approximately 20 km. These events were reported felt from the town of Battleground, Wa., to Portland, Oregon. The third earthquake reported felt in this area occurred on October 21, and differs only in that this event had a M_c = 3.0. None of these caused any damage. These events were part of a cluster of activity that began during the third quarter of 1991, with the number of events during the fourth quarter totalling 19. (Compared to 26 during the third quarter.) The Portland basin is an area of known activity and has had many earthquakes in the past.

On October 25, a M_c = 3.5 earthquake occurred 22 km northeast of Aberdeen, Wa. It was reported felt in Aberdeen, Cosmopolis, and Olympia, Wa. and had a depth of 39 km. There was a report made to the Department of Emergency Management that there was some power loss as a result of this earthquake, but no further information is available.

The final earthquake reported felt during the fourth quarter in Western Washington occurred on November 11 (UTC) 14 km east of Centralia. This had a M_c = 3.0, and a depth of approximately 15 km. There were four events preceeding this with coda magnitudes of 1.6 to 2.7, and two small events following, with coda magnitudes of 1.6 and 1.7.

Other notable activity includes a cluster of seven earthquakes 11 km northeast of Portland. These are distinct from the previously mentioned cluster to the northwest of Portland, and can be seen in Figure 2. These occurred between November 3 and November 5 (UTC). None were felt, with the largest having a M_c = 2.5, the smallest a M_c = 1.6, and all roughly 15 km deep.

Eastern Washington and Oregon

During the fourth quarter, there were 54 earthquakes located in Eastern Washington. Two were felt. The largest earthquake anywhere during the fourth quarter, registering a M_c = 4.3, located 9 km south of Walla Walla, Wa. on November 28. This event was reported felt in Milton-Freewater, Walla Walla, College Place, Pomeroy, and Dayton. This located approximately 9 km deep. There were reports of minor damage in the form of small items knocked off shelves and house shaking which was compared to heavy trucks passing by. In the following few hours, two small events occurred with magnitudes of 1.8 and 2.1, and were the only earthquakes in the area that were large enough to be recorded until a M_c = 3.3 earthquake occurred on December 15. This was also felt, though not as widely. The depth was comparable to the first event. Elsewhere, activity was normal, with the usual seismicity (totalling fifteen events) near Entiat, Wa.

Mount Rainier Area

There were 137 events in the region near Mt. Rainier, as seen in Fig. 5. Of these, 14 were located in

what is called the 'western zone', a north-south trending lineation of seismicity approximately 15 km west of the summit of Mt. Rainer. The rest were a combination of tectonic and surficial events, where tectonic events accounted for 52 and surficial events 62 of the summit events. The remaining events were scattered around the cone of Rainier as seen in Fig. 5., and probably represent poorly located events.

Activity at Mt. Rainier includes surface events (avalanches, ice quakes, etc.) and tectonic earthquakes. Earthquakes in our catalog flagged with type "L" (for low frequency), are generally surficial events. Shallow tectonic earthquakes have a higher frequency and a different source. The number of events in close proximity to the cone of Mt. Rainier varies over the course of the year, since the source of much of the shallow surface-type activity is ice movement or avalanching, which is seasonal in nature.

Mount St. Helens Area

68 events were located at Mt. St. Helens this quarter. The largest event had a M_c = 1.9 and occurred on October 2. Of the total, 15 earthquakes were deeper than 4 km, and the rest were shallower. The ratio between the 'deeper' and 'shallower' events continues to fluctuate, but there seems to be no particular importance associated with this observation during the last few years.

Earthquakes, Fourth Quarter, 1991

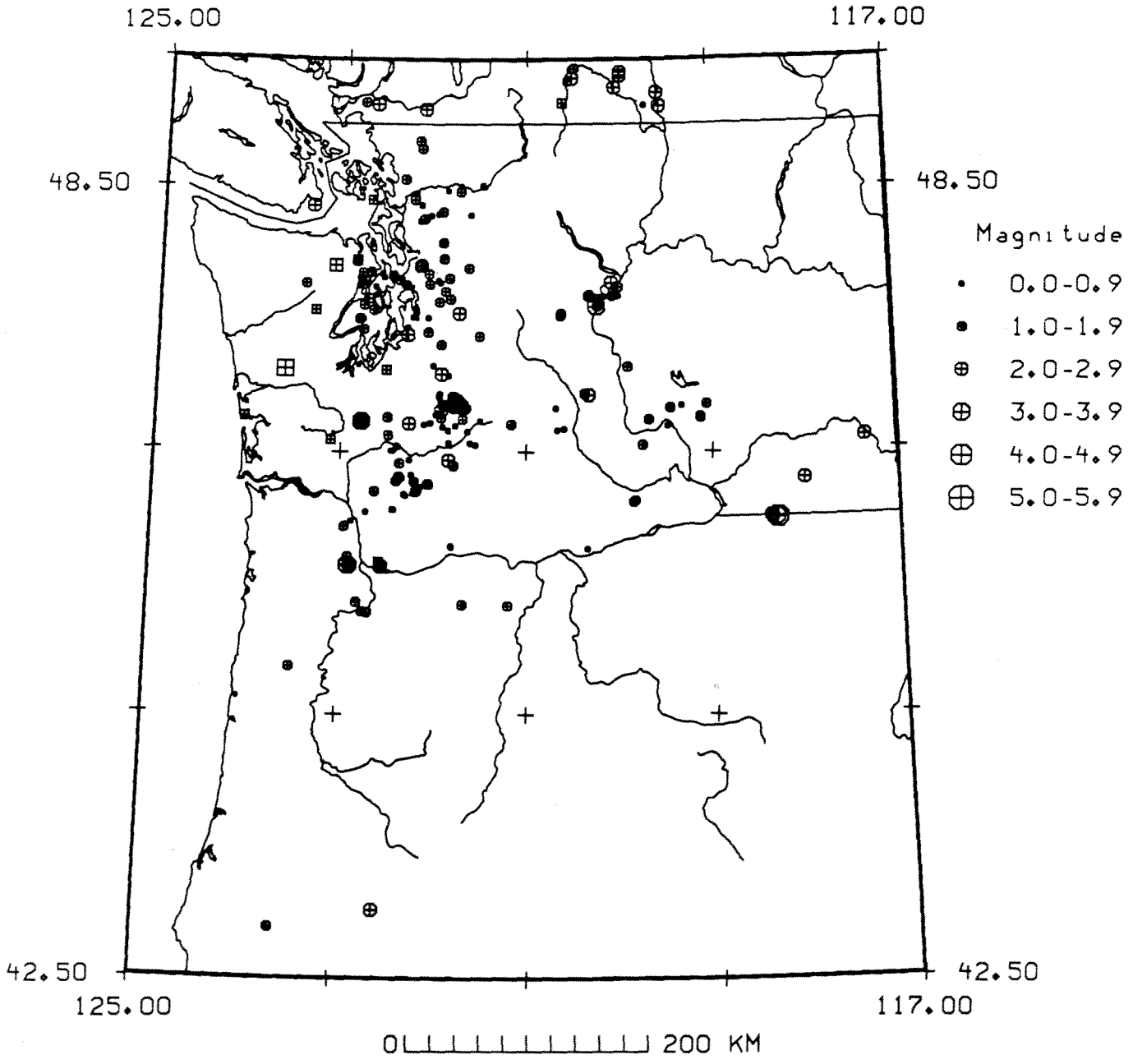

Figure 2: Earthquakes located in Washingon and Oregon, Fourth Quarter, 1991. A square symbol indicates that an event located with a depth greater or equal to 30 km. Octagonal symbols are used for events shallower than 30 km.

Blasts and Probable Blasts, Fourth Quarter, 1991

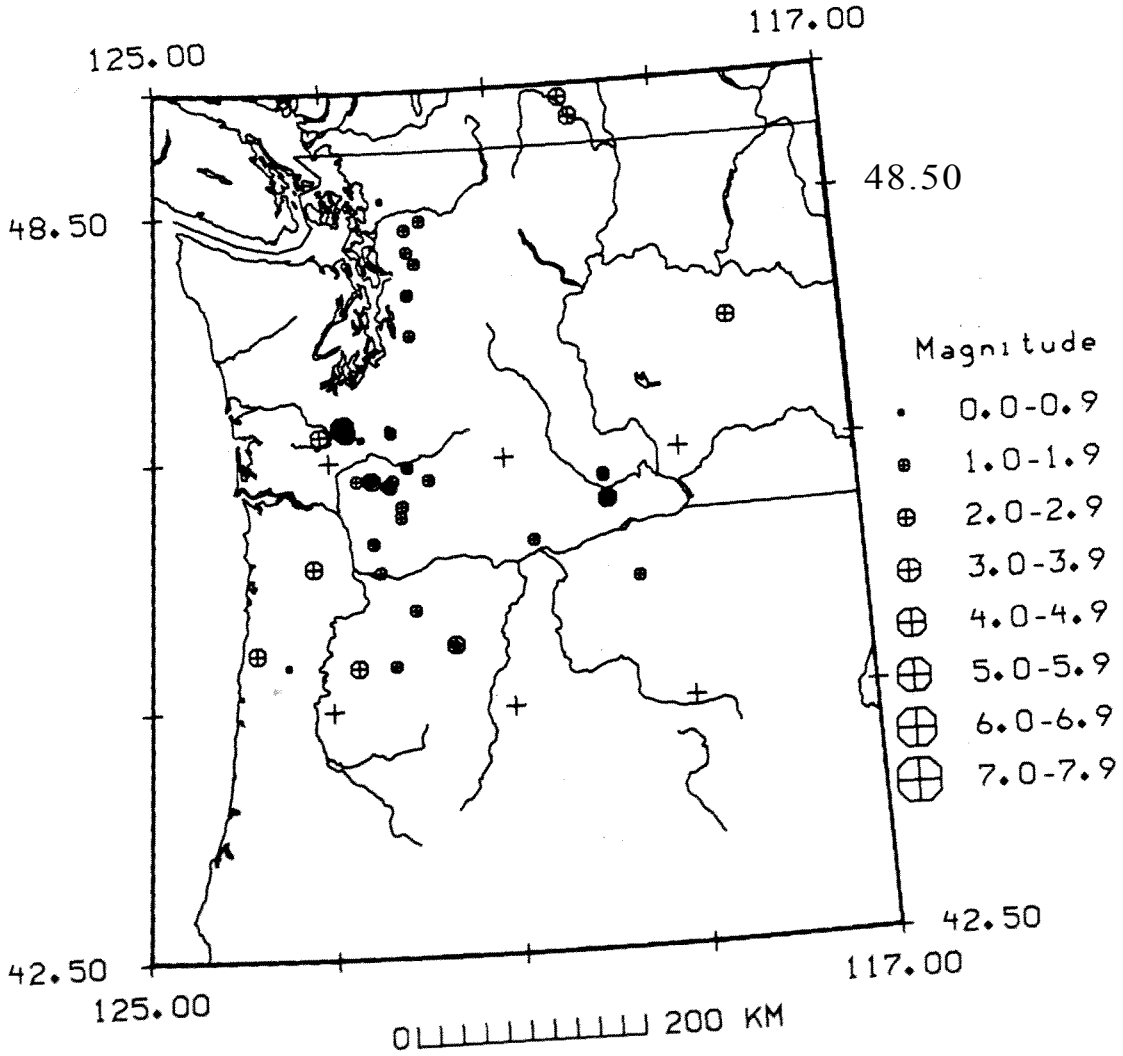

Figure 3

Mount Rainier Activity
Fourth Quarter, 1991

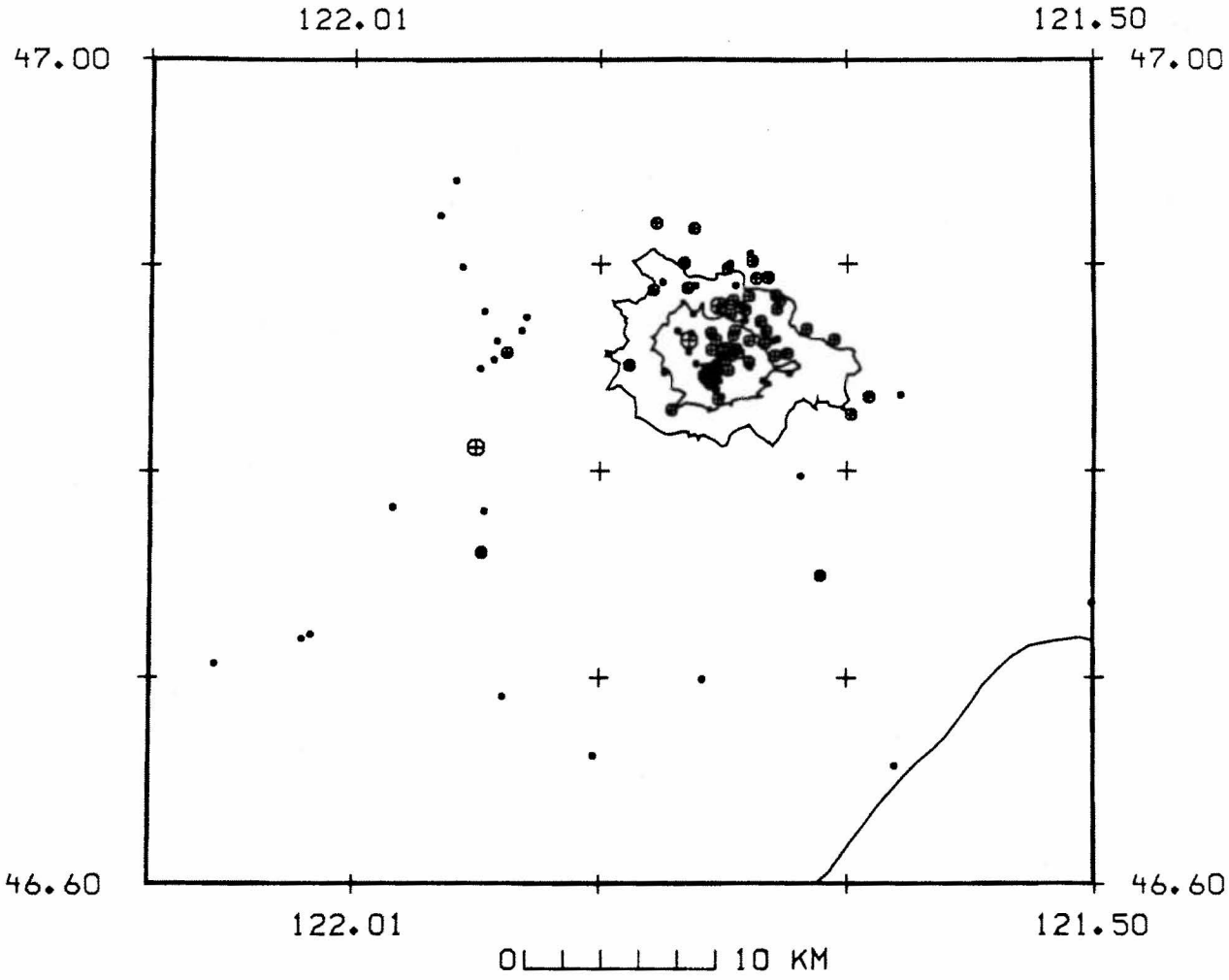

Figure 4

Mt. St. Helens Activity, Fourth Quarter, 1991

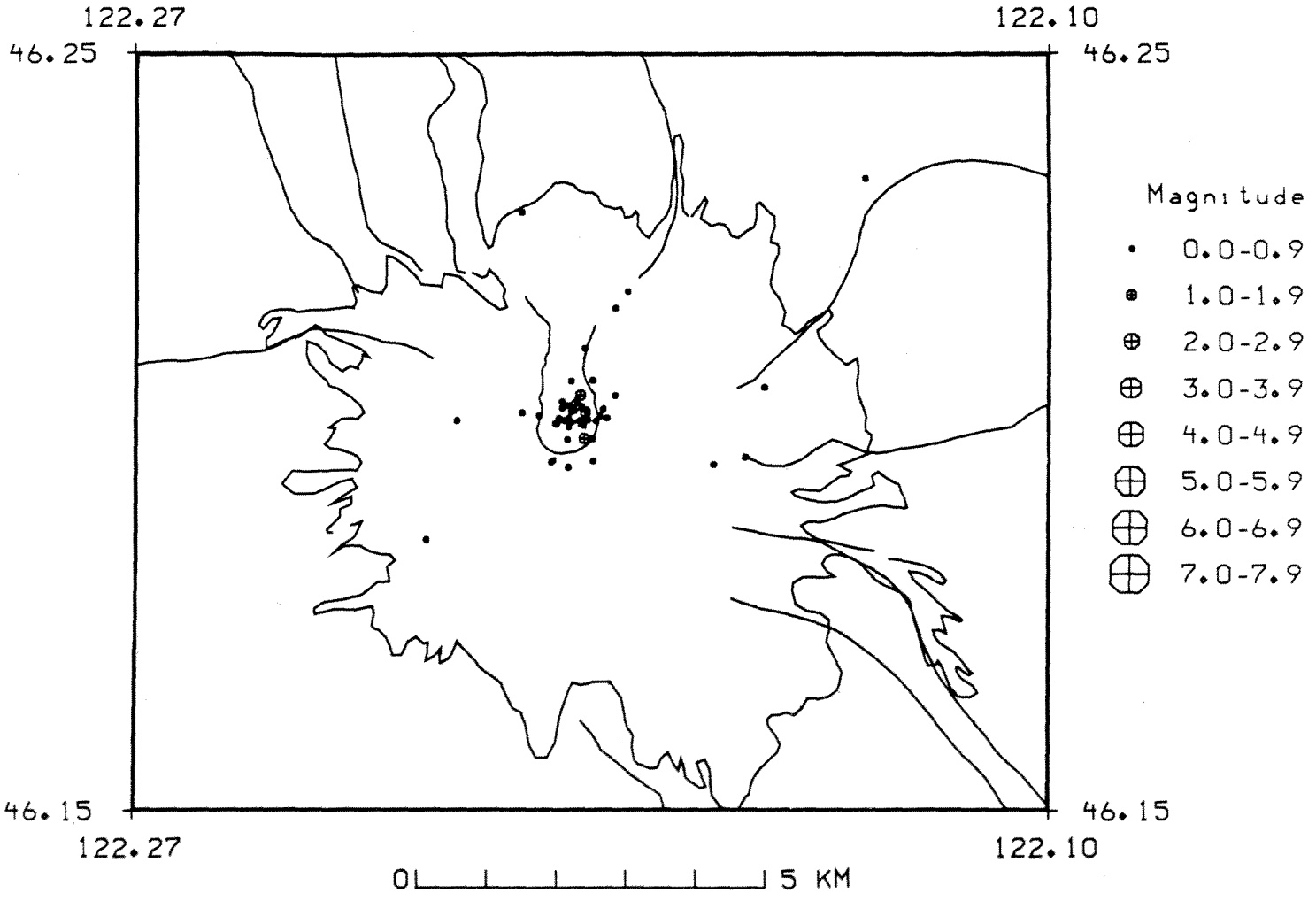

Figure 5.

Key to Earthquake Catalog in Table 3

TIME Origin time is calculated for each earthquake on the basis of multistation arrival times. Time is given in **Coordinated Universal Time** (UTC), in hours:minutes:seconds. To convert to Pacific Standard Time (PST) subtract eight hours, or to Pacific daylight time subtract seven hours.

LAT North latitude of the epicenter, in degrees and minutes.

LONG West longitude of the epicenter, in degrees and minutes.

DEPTH The depth, given in kilometers, is usually freely calculated 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.

MAG Coda-length magnitude M_c. An estimate of local Richter magnitude (Richter, C.F., 1958, Elementary Seismology: W.H. Freeman and Co., 768p), calculated using the coda-length/magnitude relationship determined for Washington (Crosson, R.S., 1972, Bull. Seism. Soc. Am., v. 62, p. 1133-1171). Where blank, data were insufficient for a reliable magnitude determination. Normally, the only earthquakes with undetermined magnitudes are very small ones. Magnitudes may be revised as we improve our analysis procedure.

NS/NP **NS** is the number of station observations, and **NP** the number of P and S phases used to calculate the earthquake location. A minimum of three stations and four phases are required. Generally, more observations improve the quality of the solution.

GAP Azimuthal gap. The largest angle (relative to the epicenter) containing no stations.

RMS The root-mean-square residual (observed arrival time minus predicted arrival time) at all stations used to locate the earthquake. It is only useful as a measure of the quality 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.

Q Two **Quality factors** indicate 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 is a measure of the hypocenter quality based on travel time residuals. For example: **A** quality requires an **RMS** less than 0.15 sec while 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, 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, **NP** , is 5 or less or **GAP** > 180° or **DMIN** > 50 km the solution is assigned quality **D.**

MOD The crustal velocity model used in location calculations.

P3 - Puget Sound model
C3 - Cascade model
S3 - Mt. St. Helens model including Elk Lake
N3 - northeastern model
E3 - southeastern model
O0 - Oregon model

TYP Events flagged in Table 3 use the following code:

F - earthquakes reported to have been felt
P - probable explosion
L - low frequency earthquakes
H - handpicked from helicorder records
X - known explosion

T A B L E 3

Earthquakes and Blasts Fourth Quarter 1991

Oct 1991

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	06:54:42.72	49 08.17	119 31.45	6.57$	2.3	9/09	262	0.27	BD	N3	
1	07:55:23.54	46 45.00	119 40.49	0.45	0.8	10/15	89	0.32	CB	E3	
1	08:59:33.45	47 34.62	122 40.26	17.81	1.3	21/24	49	0.14	AA	P3	
1	12:38:48.14	46 52.71	121 44.47	0.02*	0.0	5/05	168	0.58	DD	C3	L
1	14:54:21.20	47 32.13	120 38.18	2.72*	1.2	12/15	91	0.21	BC	C3	
1	16:13:59.35	45 18.03	122 03.59	0.04*	1.3	9/09	125	0.49	CC	O0	P
1	16:41:25.61	46 34.08	121 50.40	1.03	0.3	4/06	196	0.60	DD	C3	
1	21:17:27.25	49 22.87	120 06.03	0.04*	2.0	13/15	271	0.81	DD	N3	P
2	03:01:19.69	47 22.73	121 30.98	12.44	1.0	13/16	125	0.19	BB	C3	
2	09:00:03.42	44 58.15	123 50.45	9.30$	2.0	8/08	272	0.08	BD	P3	X
2	09:02:01.38	44 51.85	123 29.77	16.63$	0.0	12/12	169	0.27	CD	P3	X
2	09:06:00.90	44 50.93	122 42.83	0.04*	2.3	10/10	189	0.23	BD	P3	X
2	09:08:00.58	44 51.46	122 17.99	2.82	1.8	13/15	69	0.18	BC	P3	X
2	09:10:01.39	45 39.45	123 11.58	7.71$	2.5	20/20	73	0.25	BC	P3	X
2	09:12:01.05	46 42.78	123 06.03	6.11	2.4	34/34	88	0.15	AC	P3	X
2	13:37:09.10	46 50.84	121 47.76	0.03*	0.9	4/04	175	0.13	AD	C3	L
2	17:37:06.35	46 32.76	122 24.03	18.35	0.4	14/18	178	0.10	AC	C3	
2	19:30:31.69	45 49.60	120 42.00	0.02*	1.7	11/11	185	0.31	CD	C3	P
2	21:18:02.04	46 12.28	122 11.25	0.88	1.9	7/07	208	0.27	BD	S3	
2	21:40:08.71	46 55.18	121 48.09	0.57	1.5	5/05	155	0.35	CD	C3	L
3	00:00:48.94	45 36.52	122 26.34	0.03*	1.7	16/16	88	0.17	BC	C3	P
3	00:27:02.51	47 40.52	120 18.16	4.59	1.2	5/08	161	0.09	AD	N3	
3	00:40:18.24	47 39.69	121 49.96	11.85	1.0	14/17	114	0.12	AB	P3	
3	07:39:06.78	47 33.03	120 37.87	4.18	1.0	18/20	73	0.33	CC	C3	
3	08:46:33.10	46 11.94	122 11.20	1.29	1.1	6/06	120	0.08	AC	S3	
3	12:34:41.54	46 11.14	122 12.96	1.45	0.9	6/06	175	0.10	AC	S3	
3	16:48:42.79	47 52.01	122 42.63	6.88	1.0	13/15	67	0.30	BB	P3	
3	18:54:33.20	45 39.29	122 34.04	42.23*	1.6	14/14	289	0.18	BD	C3	
3	21:08:59.85	47 48.30	121 58.10	0.02*	0.6	3/04	215	0.04	AD	P3	
3	21:26:20.07	46 08.19	122 10.53	1.88	1.6	17/18	89	0.15	AA	S3	P
3	21:52:30.40	47 05.54	121 55.31	17.54	2.2	35/40	47	0.13	AA	C3	
4	01:16:41.00	46 18.13	122 19.20	0.65	1.4	24/27	64	0.13	AA	S3	P
4	02:10:04.75	46 35.85	117 21.95	0.34*	2.3	20/22	245	0.52	DD	E3	
4	08:17:29.16	47 45.81	122 50.02	18.38	0.8	8/11	106	0.13	AB	P3	
4	18:37:28.94	45 46.29	121 47.85	0.03*	0.9	16/18	83	0.18	BB	C3	
4	20:59:36.77	45 46.82	121 48.24	0.02*	0.6	8/12	96	0.16	BC	C3	
4	23:07:31.52	46 18.16	122 19.24	0.79	1.8	27/33	47	0.17	BA	S3	P
4	23:29:21.17	46 27.00	122 05.84	0.16	0.6	16/18	59	0.12	AB	S3	P
5	17:54:04.72	47 56.71	122 51.77	0.03*	1.3	11/13	72	0.13	AC	P3	
5	21:35:45.58	46 21.70	122 30.84	2.98	1.8	30/34	66	0.19	BB	C3	P
6	04:34:37.35	46 12.19	122 12.90	4.83	-0.2	7/10	104	0.13	AB	S3	
6	05:25:51.03	48 17.28	122 06.21	15.66	0.2	3/05	227	0.06	AD	P3	
6	06:34:19.62	46 50.99	121 46.01	0.04*	0.6	8/13	85	0.15	BA	C3	
6	10:12:17.79	46 53.91	121 56.11	6.07	0.7	10/16	128	0.13	AB	C3	
6	10:39:32.64	47 45.24	122 39.11	22.06	0.5	3/06	244	0.09	AD	P3	
6	13:08:48.44	46 12.12	122 11.71	1.66	0.3	7/09	96	0.06	AB	S3	
6	17:46:41.09	46 47.83	121 42.11	0.02*	0.9	3/05	274	0.35	CD	C3	L
6	19:02:20.36	46 50.35	121 45.58	0.04*	0.5	6/09	169	0.03	AC	C3	
7	04:17:32.68	46 12.08	122 11.40	1.50	0.3	9/14	92	0.06	AB	S3	
7	16:02:54.29	46 43.12	122 02.68	12.17	0.4	13/19	119	0.10	AB	C3	
7	17:43:27.27	46 50.57	121 45.84	1.05	0.1	6/09	95	0.11	AC	C3	
7	18:16:11.14	46 43.25	122 02.32	16.90	0.0	7/09	118	0.09	AB	S3	
7	19:37:13.00	47 54.80	123 05.77	43.31	2.4	31/36	71	0.22	BA	P3	
7	20:03:17.85	48 36.50	122 18.38	0.05*	0.9	4/05	268	0.31	CD	P3	P
7	21:52:06.84	46 21.53	122 30.91	1.79	1.8	34/37	51	0.18	BB	C3	P
7	21:57:24.33	46 27.31	122 06.37	1.00	0.8	21/22	58	0.17	BB	C3	P
7	23:15:23.85	47 30.60	122 01.53	0.02*	1.1	17/18	82	0.25	BC	P3	P
8	00:25:28.00	46 17.89	122 18.95	1.21	1.2	21/21	97	0.20	BB	S3	P
8	05:40:13.89	46 51.75	121 43.27	0.03#	0.0	5/05	184	0.20	BD	C3	L
8	08:41:54.16	46 12.01	122 11.35	0.04*	-0.2	7/12	94	0.07	AB	S3	

Oct 1991 cont'd

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
8	08:59:59.77	44 51.47	123 28.75	21.84	1.9	28/28	168	0.33	CD	O0	
8	11:46:35.60	46 54.07	121 44.12	6.77	1.6	5/05	126	0.24	BD	C3	L
8	12:04:33.85	46 12.09	122 11.47	1.64	0.0	8/09	93	0.08	AB	S3	
8	17:59:19.24	46 14.00	122 08.06	0.02*	0.5	8/09	161	0.37	CC	S3	
8	18:15:23.63	46 43.15	122 16.38	0.04*	0.9	10/12	193	0.31	CD	C3	P
8	19:43:31.16	45 55.76	122 56.16	23.60	1.5	33/37	70	0.23	BB	C3	
8	21:36:16.61	46 46.83	121 55.18	6.75	0.0	6/09	212	0.08	AD	C3	
8	23:10:05.02	47 31.20	122 04.69	0.02*	0.9	8/10	113	0.35	CC	P3	
9	00:31:37.69	46 18.06	122 20.18	2.51	1.0	16/18	126	0.21	BB	S3	P
9	00:38:57.44	46 12.08	122 11.26	1.68	0.3	9/12	90	0.06	AA	S3	
9	01:30:32.02	46 21.45	122 31.34	4.32	1.6	31/36	84	0.17	BB	C3	P
9	02:05:13.61	46 12.10	122 11.49	1.12	0.1	8/10	93	0.05	AB	S3	
9	09:03:32.15	46 11.87	122 37.59	16.45	1.1	21/30	108	0.11	AB	C3	
9	13:35:02.43	46 12.05	122 11.17	1.73	-0.1	8/09	88	0.04	AA	S3	
9	13:53:49.44	46 44.50	119 40.99	0.04*	1.7	13/17	51	0.30	CB	E3	
9	15:32:14.07	47 04.88	121 50.76	10.38$	0.1	8/12	123	0.23	BB	C3	
9	17:46:39.29	46 43.19	122 15.01	0.04*	0.5	7/09	188	0.19	BD	C3	P
9	18:21:04.75	46 44.00	122 16.78	0.05*	0.5	7/08	197	0.29	BD	C3	P
9	18:23:37.33	46 50.99	121 45.57	0.04*	1.2	12/17	59	0.15	BA	C3	
9	20:36:57.00	46 54.02	121 46.94	0.89	1.6	5/05	129	0.41	CD	C3	L
9	22:10:51.39	46 46.85	122 49.96	6.57	3.1	17/17	91	0.08	AC	P3	X
9	23:53:17.06	46 26.95	122 06.19	1.95	1.0	22/26	58	0.11	AB	S3	P
10	10:45:34.51	46 51.78	121 46.73	0.03*	2.1	4/04	179	0.22	BD	C3	L
10	11:33:13.22	46 51.76	121 44.24	0.04*	1.1	5/05	173	0.27	BD	C3	L
10	17:44:06.76	46 43.67	122 15.07	0.02*	0.7	6/08	190	0.41	CD	C3	P
10	23:58:18.26	46 17.38	122 18.41	0.71	1.2	16/20	105	0.31	CB	S3	P
11	00:03:44.45	47 50.50	122 02.05	0.02#	1.2	5/09	165	0.35	CD	P3	P
11	10:14:36.78	46 51.44	121 46.75	0.03*	0.9	5/05	123	0.43	CD	C3	L
11	19:03:16.94	49 13.44	119 59.52	0.02*	2.0	10/10	266	0.56	DD	N3	P
11	20:02:23.75	46 39.87	120 39.88	12.16	0.8	5/08	114	0.19	BD	E3	
11	23:32:41.60	46 21.23	122 32.08	4.77	1.4	25/31	89	0.21	BB	C3	P
11	23:34:46.71	46 18.05	122 19.09	1.28	0.9	19/20	64	0.09	AA	S3	P
12	00:00:41.11	46 50.88	121 45.77	0.03*	2.4	41/45	44	0.28	BA	C3	
12	00:12:33.12	46 50.80	121 46.14	0.03*	0.4	6/10	90	0.11	AC	C3	
12	01:14:07.77	46 50.81	121 42.59	0.03*	0.5	4/06	199	0.16	BD	C3	L
12	03:24:51.76	48 48.52	122 10.03	0.02*	1.6	13/14	204	0.56	DD	P3	
12	13:38:21.48	46 24.77	122 21.84	17.70	1.0	23/31	54	0.13	AA	S3	
13	04:58:23.82	47 50.43	122 27.87	21.98	1.8	23/26	48	0.12	AA	P3	
13	06:02:11.44	46 12.24	122 11.28	4.39	0.1	9/14	90	0.08	AA	S3	
13	10:21:02.05	46 15.99	122 12.84	7.34	0.0	10/19	107	0.08	AB	S3	
13	21:04:30.20	46 50.72	121 45.56	0.04*	0.2	7/11	97	0.11	AB	C3	
14	02:25:31.67	46 50.81	121 46.22	0.96	0.8	5/05	147	0.27	BD	C3	L
14	20:41:33.89	46 44.11	122 16.66	0.02*	0.8	14/15	187	0.29	BD	C3	P
14	22:21:33.17	47 26.78	122 17.70	11.11	0.7	14/16	105	0.21	BB	P3	
15	00:52:27.71	46 17.45	122 17.77	0.03*	1.3	14/17	65	0.32	CA	S3	P
15	10:13:08.93	46 52.00	121 43.63	4.11	0.0	5/05	178	0.34	DD	C3	L
15	15:20:22.51	46 53.59	121 43.47	0.05*	1.3	5/05	153	0.28	BD	C3	L
15	17:42:52.43	46 43.84	122 16.74	1.88*	1.1	22/22	84	0.30	CB	C3	P
15	19:01:14.07	46 21.43	122 30.86	1.50	1.7	23/23	65	0.12	AB	C3	P
15	19:24:07.12	44 59.99	121 39.14	0.03*	1.6	5/05	163	0.35	CD	O0	P
15	20:07:19.66	45 29.37	119 32.00	0.03*	1.6	12/13	151	0.39	CC	O0	P
15	20:40:43.94	48 05.52	121 55.77	0.83	1.3	11/13	99	0.27	BC	P3	P
16	00:15:59.99	46 18.08	122 19.04	1.17	0.9	21/24	89	0.07	AA	S3	P
16	05:22:01.45	46 54.01	121 45.03	0.02*	0.8	4/04	195	0.41	CD	C3	L
16	17:38:08.83	47 51.20	122 04.37	23.40	1.2	14/19	71	0.10	AA	P3	
16	19:47:11.72	46 45.97	122 18.56	0.02*	0.9	7/09	210	0.29	BD	P3	P
16	23:48:43.80	46 18.48	122 19.57	0.80	1.9	23/25	59	0.11	AA	S3	P
17	00:41:54.26	47 49.25	121 50.63	12.16	1.4	13/17	82	0.13	AA	P3	
17	06:38:25.05	46 50.93	121 45.80	0.04*	0.1	7/13	91	0.09	AB	C3	
17	18:11:43.49	46 12.09	122 11.16	2.82	0.4	8/12	87	0.06	AA	S3	
17	19:25:02.86	46 20.58	122 16.57	1.84	1.2	18/21	70	0.12	AA	S3	P
17	21:16:03.54	46 50.59	121 45.47	0.04*	0.2	6/11	101	0.21	BC	C3	
17	22:28:08.40	46 12.03	122 11.37	1.63	0.4	8/10	93	0.06	AB	S3	
17	23:03:19.10	46 12.09	122 11.43	1.66	-0.3	8/10	92	0.05	AB	S3	
17	23:51:05.78	48 25.01	122 42.69	49.09	1.5	18/18	95	0.17	BB	P3	

Oct 1991 cont'd

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
18	00:16:33.72	46 17.86	122 19.56	1.22	1.1	18/20	113	0.14	AB	S3	P
18	02:21:46.86	47 30.69	122 47.14	13.87	0.7	8/09	99	0.31	CB	P3	
18	02:49:41.19	45 38.22	122 52.71	18.59	1.7	36/42	65	0.24	BA	C3	
18	02:49:51.89	45 37.97	122 53.76	20.18	3.1	32/35	83	0.18	BA	C3	F
18	03:00:42.20	45 37.58	122 53.39	16.45	1.4	12/16	311	0.14	BD	C3	
18	03:26:42.35	45 37.71	122 53.01	16.70	1.2	13/17	310	0.12	BD	C3	
18	03:44:39.50	45 38.14	122 52.64	18.99	1.2	16/22	100	0.13	AB	C3	
18	07:06:55.97	45 38.27	122 52.31	19.32	1.5	25/29	100	0.17	BB	C3	
18	07:45:49.02	45 38.39	122 52.68	20.45	1.7	31/34	65	0.19	BA	C3	
18	10:34:44.44	45 37.50	122 51.71	17.45	1.0	20/24	100	0.16	BB	C3	
18	12:52:12.05	45 38.30	122 51.99	16.90*	0.9	13/17	127	0.16	BB	C3	
18	19:47:21.73	47 41.62	122 38.95	15.51$	0.8	10/17	78	0.19	BB	P3	
18	19:57:38.81	45 37.99	122 51.69	18.69	2.8	36/40	47	0.14	AA	C3	F
18	20:03:14.89	46 11.76	122 11.55	3.86	0.3	5/07	108	0.05	AD	S3	
18	21:10:35.96	47 50.25	122 02.23	0.02*	1.8	12/13	73	0.35	CA	P3	P
18	21:25:54.95	46 11.93	122 11.39	3.46*	0.1	6/09	98	0.05	AC	S3	
18	21:46:04.55	45 38.61	122 52.97	24.02	1.3	26/29	109	0.30	BB	C3	
19	01:25:58.52	46 17.90	122 16.31	0.86	0.7	18/19	70	0.11	AB	S3	P
19	01:28:34.67	47 33.35	121 44.28	13.83	2.2	28/31	106	0.14	AB	P3	
19	07:21:11.46	47 42.95	120 03.68	6.02	1.0	5/09	135	0.12	AD	N3	
19	08:00:19.57	46 26.42	122 15.59	6.08	0.3	16/20	86	0.13	AA	S3	
19	08:43:29.12	46 18.69	122 22.19	16.29	1.1	17/20	136	0.11	AC	S3	
19	11:08:55.18	46 12.34	122 09.19	12.64	0.2	7/11	148	0.22	BC	S3	
19	15:18:41.90	47 09.10	122 00.98	18.69	0.9	13/20	147	0.13	AC	P3	
19	16:30:02.89	46 23.76	121 47.11	0.12*	1.0	4/06	195	0.15	AD	C3	
19	17:46:09.60	47 24.59	122 04.30	18.22	1.5	19/21	175	0.10	AC	P3	
19	17:53:30.79	46 20.92	122 30.69	0.20	2.0	25/27	78	0.08	AB	S3	P
20	02:17:37.65	45 38.39	122 52.79	19.41	1.7	31/33	77	0.21	BA	C3	
20	04:46:02.87	46 49.68	119 27.50	3.14*	0.9	13/18	102	0.17	BB	E3	
20	04:53:54.60	46 51.05	121 49.20	0.02*	1.3	5/05	107	0.09	AD	C3	L
20	08:49:13.82	46 12.15	122 11.35	2.05	0.1	10/11	75	0.10	AA	S3	
20	13:07:38.19	46 16.28	122 12.65	7.02	0.0	10/19	113	0.04	AB	S3	
21	00:49:10.59	46 10.00	122 17.67	11.21	0.2	11/17	88	0.21	BA	S3	
21	00:51:01.12	45 37.87	122 53.23	20.38	3.0	40/46	48	0.25	BA	C3	F
21	07:52:35.61	46 51.09	121 46.44	0.78*	0.5	7/10	94	0.18	BB	C3	
21	16:30:51.10	46 17.43	122 16.49	0.45	0.3	9/16	103	0.11	AB	S3	P
21	18:57:15.67	46 17.07	122 13.09	6.53	0.2	11/17	57	0.07	AA	S3	
22	02:06:27.27	46 18.06	122 20.13	0.29	1.1	17/20	126	0.15	AB	S3	P
22	03:15:23.53	46 11.73	122 09.75	11.04	0.1	11/15	58	0.10	AA	S3	
22	06:03:55.71	45 38.09	122 52.03	19.57	1.8	32/35	77	0.16	BA	C3	
22	07:57:20.68	45 39.09	122 53.04	17.26	1.6	26/28	103	0.27	BB	C3	
22	19:43:21.48	45 37.98	122 52.44	20.42	2.1	34/38	66	0.13	AA	C3	
22	21:36:00.48	48 26.39	121 51.11	0.03*	1.0	6/08	93	0.31	CC	P3	P
23	00:14:41.04	47 57.58	122 51.34	44.35	1.4	19/21	59	0.22	BA	P3	
23	15:26:00.76	46 51.21	121 54.79	5.43	0.8	8/12	101	0.09	AB	C3	
23	22:26:52.33	47 49.41	122 03.86	0.02#	0.6	4/06	219	0.38	CD	P3	P
23	23:35:20.70	46 19.65	122 14.26	12.34	0.6	11/17	87	0.05	AA	S3	
24	00:47:25.10	46 18.16	122 16.77	1.69	0.3	21/26	48	0.13	AA	S3	P
24	03:39:26.87	46 37.63	122 29.36	15.56	1.0	15/20	196	0.14	AD	C3	
24	07:19:37.62	46 39.70	121 50.63	5.20	0.4	7/12	221	0.06	AD	C3	
24	18:38:34.71	46 42.59	121 09.80	5.10	1.1	15/22	94	0.23	BC	C3	
24	19:40:22.57	46 07.01	119 50.53	0.02*	1.9	16/16	159	0.26	BC	E3	P
25	04:29:42.33	46 12.23	122 11.51	2.90	-0.1	9/15	89	0.15	AA	S3	
25	05:57:16.16	46 49.82	119 27.03	2.34	0.3	6/11	139	0.26	CC	E3	
25	06:26:58.99	46 03.65	122 25.24	19.40	0.7	15/18	187	0.13	AD	S3	
25	10:52:06.19	47 40.70	120 09.70	6.09	0.4	5/09	155	0.13	AD	N3	
25	15:42:06.26	47 07.40	123 37.05	38.65*	3.4	44/46	117	0.22	BB	P3	F
25	17:47:31.03	46 41.52	119 28.76	0.02*	0.5	7/10	97	0.05	AB	E3	
25	22:41:51.97	48 05.53	121 55.94	0.02*	1.1	11/12	121	0.24	BC	P3	P
25	22:54:31.66	46 52.62	121 55.19	11.77	0.3	10/17	101	0.15	AB	C3	
25	23:29:31.78	48 05.42	121 55.12	0.04*	1.2	11/14	123	0.29	BC	P3	
25	23:35:58.42	46 07.43	119 50.56	0.04*	2.2	26/27	63	0.40	CC	E3	P
26	01:03:53.54	46 12.16	122 11.23	3.92	-0.4	8/12	86	0.11	AA	S3	
26	08:11:13.52	45 19.98	121 40.85	3.60*	1.2	22/25	74	0.35	CB	O0	
26	08:13:53.47	46 44.21	122 47.51	21.31	2.1	32/37	56	0.43	CB	P3	

Oct 1991 cont'd

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
26	08:45:30.65	46 43.88	122 48.05	16.87	1.4	23/25	87	0.29	BC	P3	
26	15:46:34.94	46 49.74	119 27.13	0.03*	1.1	4/04	140	0.02	AD	E3	
26	18:41:53.59	46 52.72	121 45.39	0.04*	1.9	4/04	179	0.48	CD	C3	L
26	18:50:51.49	46 12.05	122 11.24	2.90	0.1	8/13	90	0.09	AA	S3	
26	19:06:16.68	46 12.08	122 11.08	3.80	-0.3	7/12	119	0.04	AB	S3	
27	07:31:20.98	46 12.15	122 11.19	3.01	1.4	25/32	49	0.09	AA	S3	
27	18:13:10.40	48 28.31	122 13.50	6.37	0.2	4/07	250	0.07	AD	P3	
27	18:30:57.84	47 47.41	121 56.63	3.27	0.6	6/09	137	0.10	AC	P3	
28	13:17:35.66	46 12.19	122 11.23	2.53	0.0	11/16	74	0.05	AA	S3	
28	16:29:58.15	46 12.11	122 11.58	5.10	-0.5	6/09	94	0.04	AC	S3	
28	18:36:18.03	45 45.61	120 20.66	0.02*	0.9	8/08	301	1.82	DD	E3	
28	18:43:27.69	46 07.74	119 49.88	0.24	1.5	10/12	155	0.33	CC	E3	
28	20:37:00.95	46 10.49	122 18.88	10.58	0.1	12/18	121	0.06	AB	S3	
29	01:02:52.54	46 07.34	119 50.19	0.04*	1.7	21/21	64	0.33	CC	E3	P
29	18:01:28.80	46 18.49	119 52.38	0.04*	1.4	15/15	110	0.37	CC	E3	P
29	21:08:08.45	48 11.11	122 01.22	0.02*	1.0	6/07	163	0.18	BC	P3	P
30	00:37:49.78	46 07.50	119 50.36	0.02*	2.1	29/32	64	0.28	BC	E3	P
30	05:45:22.89	47 49.67	122 33.77	18.44	0.6	8/11	92	0.13	AB	P3	
30	06:08:50.24	46 33.90	121 36.57	3.83	0.5	8/12	130	0.13	AB	C3	
30	06:39:18.09	47 43.17	121 53.38	23.22	1.2	22/26	77	0.19	BA	P3	
30	16:16:54.37	47 46.41	123 24.72	12.22	1.9	22/25	109	0.14	AB	P3	
30	18:24:45.55	46 52.54	121 46.56	0.04*	0.9	5/05	189	0.35	CD	C3	L
31	17:03:34.88	49 06.69	122 07.87	0.05*	2.0	9/11	281	0.24	BD	P3	
31	22:02:47.52	47 18.95	121 55.80	3.54	1.9	5/05	206	0.18	CD	P3	
31	23:09:02.73	47 31.66	118 20.01	0.69	2.0	11/12	201	0.51	DD	N3	P

Nov 1991

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	01:16:07.94	46 40.91	122 37.48	0.02*	0.9	11/13	253	0.22	BD	P3	P
1	06:25:01.65	47 53.76	121 38.04	10.32	1.1	14/18	137	0.21	BC	P3	
1	12:45:59.41	46 54.28	121 44.21	0.04*	0.9	4/04	191	0.46	CD	C3	L
1	14:29:19.66	46 12.08	122 11.42	0.20	0.4	8/08	93	0.11	AB	S3	
1	23:54:21.16	48 18.10	122 03.46	11.58	0.7	5/10	182	0.14	AD	P3	
2	03:51:03.09	46 51.80	121 43.09	0.04*	0.9	5/05	186	0.33	CD	C3	L
2	06:06:02.62	46 51.92	121 44.90	2.30	1.3	5/05	135	0.26	BD	C3	L
2	18:04:00.69	48 34.60	122 20.81	0.02*	1.2	8/10	127	0.27	BC	P3	
3	00:26:09.03	45 36.84	122 32.08	18.52	1.6	28/30	72	0.23	BA	C3	
3	01:30:48.85	45 37.29	122 32.86	15.82	2.5	35/43	67	0.16	BB	C3	
3	03:48:13.47	45 37.37	122 33.03	15.43*	1.8	28/29	67	0.20	BB	C3	
3	08:25:29.57	45 37.36	122 33.32	14.11	1.9	36/39	67	0.19	BB	C3	
3	11:33:35.75	46 12.16	122 11.31	2.03	0.4	10/12	88	0.06	AA	S3	
3	11:44:46.66	48 52.01	122 11.51	0.05*	1.9	14/16	227	0.55	DD	P3	
3	15:07:53.39	47 34.42	123 17.88	45.05	1.4	20/23	74	0.19	BA	P3	
3	15:14:32.97	46 53.37	121 44.81	3.37	0.0	9/09	98	0.42	CB	C3	L
4	03:43:42.61	46 51.03	121 45.97	1.03	0.3	6/10	92	0.13	AC	C3	
4	09:46:50.45	46 50.62	121 45.94	0.04*	1.1	8/13	88	0.10	AA	C3	
4	09:56:56.48	46 50.42	121 45.90	0.22*	0.1	8/12	86	0.16	BA	C3	
4	09:57:00.15	46 50.13	121 45.38	0.68	0.4	6/09	104	0.04	AC	C3	
4	09:57:25.65	46 50.83	121 46.82	1.90	-0.4	5/07	162	0.10	BD	C3	
4	10:21:34.54	46 53.47	121 47.82	0.03*	0.0	4/04	217	0.54	DD	C3	L
4	10:39:34.99	46 50.73	121 46.12	0.03*	1.5	17/22	63	0.21	BA	C3	
4	12:05:42.03	46 50.49	121 45.79	0.33	0.2	6/10	97	0.08	AC	C3	
4	13:47:10.11	46 17.48	122 12.98	5.98*	0.4	15/23	68	0.06	AB	S3	
4	13:59:16.10	46 50.85	121 45.47	0.37	0.1	6/10	97	0.08	AC	C3	
4	16:48:50.48	45 37.27	122 32.97	16.44	1.9	25/28	74	0.13	AB	C3	
4	22:49:28.11	48 25.54	122 14.50	0.04*	1.8	12/14	89	0.29	BB	P3	
5	00:14:13.27	46 07.41	119 50.10	0.04*	2.0	14/15	116	0.27	BC	E3	P
5	02:57:55.00	45 41.67	122 53.95	23.90$	1.3	22/24	143	0.23	BC	C3	
5	04:18:37.04	46 12.18	122 11.45	1.95	0.9	14/20	55	0.10	AA	S3	
5	04:51:39.96	46 12.05	122 11.51	2.24	0.7	9/14	96	0.07	AB	S3	
5	05:01:18.59	45 38.15	122 31.51	15.19	1.8	22/24	72	0.16	BB	P3	
5	19:07:17.95	47 55.12	122 09.83	16.42	1.5	22/26	74	0.15	AB	P3	
6	00:05:44.01	46 07.28	119 49.37	0.02*	1.8	8/08	143	0.28	BC	E3	P
6	11:24:52.29	46 45.16	119 07.55	20.62	1.1	17/25	119	0.18	BB	E3	

Nov 1991 cont'd

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
6	14:30:29.84	47 51.36	122 34.89	17.91	0.7	11/13	93	0.12	AB	P3	
6	14:56:52.68	46 12.06	122 11.53	0.79*	0.2	9/14	96	0.07	AB	S3	
6	21:14:51.32	46 19.40	119 52.76	0.02*	1.6	14/17	133	0.27	BC	E3	P
6	23:18:02.08	46 51.14	121 44.25	5.84	1.7	6/06	112	0.21	BC	C3	L
7	00:04:49.00	46 08.31	119 49.46	0.02*	1.7	11/11	142	0.31	CC	E3	P
7	06:55:56.04	46 45.60	119 07.87	20.11	1.1	15/21	119	0.19	BB	E3	
7	12:45:57.95	46 12.65	122 11.20	2.10	0.6	7/08	166	0.20	BC	S3	
7	17:38:39.76	46 02.58	122 43.07	14.19	0.9	16/21	257	0.15	AD	C3	
7	20:24:07.28	46 20.45	121 52.03	1.03	1.0	16/19	96	0.07	AC	S3	P
7	23:20:01.11	46 44.00	122 48.30	7.05$	2.8	26/30	53	0.27	BC	P3	P
8	00:03:55.44	46 45.71	122 30.14	17.43	1.8	18/24	75	0.09	AB	P3	
8	02:21:28.65	46 50.59	121 46.12	0.05*	0.6	12/17	90	0.13	AA	C3	
8	07:33:27.35	47 50.79	122 27.72	19.34	0.7	11/18	84	0.14	AA	P3	
8	09:33:08.33	46 50.87	121 45.53	0.87*	-0.4	6/09	96	0.20	BC	C3	
8	15:38:37.19	46 56.44	121 56.39	12.81	0.1	7/11	120	0.28	BB	C3	
8	16:34:18.64	46 32.88	119 45.00	19.66	1.8	29/40	34	0.25	BA	E3	
8	18:40:52.81	46 07.12	119 50.94	0.03*	1.5	7/08	160	0.22	BC	E3	
9	17:13:59.04	46 44.11	122 47.44	7.43*	2.6	42/43	52	0.13	AC	P3	
9	20:54:27.56	46 44.70	122 46.12	14.70	1.6	21/24	77	0.26	BC	P3	
9	20:54:47.44	46 17.34	122 22.87	16.80	1.1	17/25	144	0.07	AC	S3	
9	22:10:46.23	45 16.34	122 40.90	25.40	1.8	33/35	104	0.36	CB	O0	
10	01:50:07.86	46 51.21	121 45.21	0.04*	1.7	5/05	159	0.12	AD	C3	L
10	02:06:10.80	46 44.23	122 46.94	17.04	2.7	41/43	52	0.20	BC	P3	
10	09:00:36.10	46 12.20	122 11.40	0.95	0.4	8/10	88	0.08	AA	S3	
10	09:08:15.90	46 43.76	122 47.02	14.86$	3.0	57/63	52	0.41	CC	P3	F
10	14:29:02.08	46 12.04	122 11.21	2.04	0.9	12/20	90	0.07	AA	S3	
10	15:17:15.12	46 12.07	122 11.34	1.91	0.4	8/09	91	0.07	AB	S3	
10	19:57:58.71	47 47.13	120 04.67	2.72	2.0	23/28	76	0.26	BA	N3	
10	20:14:42.75	46 12.04	122 11.21	2.10	0.6	12/17	90	0.06	AA	S3	
11	07:42:02.76	46 53.30	121 46.81	0.02*	1.2	6/08	122	0.45	CC	C3	L
11	10:15:17.58	46 44.15	122 47.69	7.94*	1.7	18/18	86	0.10	AC	P3	
11	12:25:05.63	46 44.02	122 48.19	21.79	1.6	14/18	87	0.25	BB	P3	
11	16:44:00.83	48 29.47	121 52.48	19.96*	0.8	4/07	109	0.35	CD	P3	
12	03:11:09.82	46 50.92	119 20.01	0.03*	0.9	11/15	104	0.14	AB	E3	
12	07:40:57.74	47 07.41	122 31.38	50.60	1.6	26/26	62	0.20	BA	P3	
12	12:59:29.07	48 28.98	121 43.98	1.95	1.4	8/12	123	0.36	CC	P3	
13	03:01:18.54	46 51.67	121 43.61	4.89	1.3	6/06	105	0.24	BC	C3	L
13	06:45:29.11	46 11.79	122 09.40	8.34	0.3	13/21	90	0.10	AA	S3	
13	20:03:41.95	49 19.56	120 32.84	19.05$	1.7	14/15	254	0.75	DD	C3	R
14	23:01:29.20	47 23.52	122 17.53	12.46	2.0	41/44	37	0.22	BB	P3	
15	19:16:07.71	46 51.75	121 54.67	10.67	0.4	8/14	184	0.12	AD	C3	
15	21:27:41.10	46 15.39	122 03.00	11.75	0.0	11/18	141	0.05	AC	S3	
16	00:51:51.05	46 17.16	118 01.08	0.02*	2.3	25/25	241	0.39	CD	E3	
16	08:57:29.70	46 12.23	122 11.45	1.61	0.3	10/13	68	0.12	AA	S3	
16	10:37:09.60	46 49.75	121 47.45	0.81	1.7	5/05	110	0.39	CD	C3	L
16	22:52:25.23	46 49.71	120 41.29	16.32	0.9	9/12	112	0.44	CB	E3	
16	23:24:22.96	46 12.10	122 10.95	1.09	0.9	5/08	197	0.12	AD	S3	
17	01:53:30.77	46 12.40	122 11.11	0.02*	0.9	7/08	147	0.12	AC	S3	
17	18:13:27.30	46 51.01	121 46.11	0.02*	0.2	5/09	107	0.15	AD	C3	
18	21:18:47.05	46 50.06	121 45.53	0.05*	1.3	4/04	174	0.24	BD	C3	L
19	01:08:59.41	48 15.44	122 10.59	10.26	0.7	5/07	224	0.11	BD	P3	
19	10:43:02.72	46 51.99	121 45.82	0.02*	1.5	4/04	172	0.05	AD	C3	L
19	10:47:37.19	46 51.46	121 45.32	0.03*	1.7	18/22	63	0.25	BA	C3	
19	10:48:15.59	46 51.88	121 45.83	0.04*	0.8	7/11	101	0.15	AB	C3	
19	23:35:00.69	45 50.77	122 28.71	0.03*	0.0	6/07	308	0.15	AD	C3	P
20	03:15:54.93	46 50.90	121 45.10	0.03*	1.6	5/05	170	0.10	AD	C3	L
20	09:37:33.62	46 12.30	122 11.79	4.87	-0.1	8/11	90	0.12	AA	S3	
20	10:07:54.95	46 12.17	122 10.99	0.05*	0.8	5/05	202	0.10	AD	S3	
20	14:49:53.18	46 39.42	121 38.20	4.77	0.1	6/10	139	0.05	AC	C3	
20	21:27:41.68	47 37.00	122 46.61	12.78	1.1	16/19	94	0.13	AB	P3	
21	15:56:01.76	46 50.95	121 55.35	8.27	0.1	7/13	197	0.12	AD	C3	
21	19:10:42.99	43 01.32	122 34.64	20.36	2.1	5/07	172	0.24	BD	O0	
21	21:07:27.23	46 12.06	122 11.17	4.53	-0.3	6/11	118	0.17	BC	S3	
22	14:34:21.50	48 16.46	122 08.05	11.62	1.0	8/12	83	0.13	AB	P3	
22	16:09:38.46	46 26.25	121 50.39	10.48$	2.0	28/40	97	0.11	AC	S3	

Nov 1991 cont'd

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
22	18:51:19.89	46 51.78	121 46.58	0.03*	-0.3	6/10	102	0.14	AC	C3	
22	22:42:19.30	46 41.45	121 54.39	7.55	0.6	10/16	90	0.10	AB	C3	
23	00:17:22.16	46 46.84	122 50.18	0.03*	2.0	17/17	91	0.18	BC	P3	P
23	00:28:25.31	47 52.54	122 41.83	0.02*	0.9	11/13	78	0.21	BB	P3	
24	02:03:12.95	46 55.02	121 46.53	0.53	1.3	4/04	226	0.29	CD	C3	L
24	04:13:13.83	46 50.85	121 54.07	12.01	-0.2	6/10	185	0.15	BD	C3	
24	16:08:55.79	46 52.68	121 43.11	0.04#	1.1	4/04	178	0.65	DD	C3	L
24	18:02:14.68	46 12.01	122 11.45	2.34	-0.1	8/11	96	0.08	AB	S3	
24	21:11:22.49	47 36.25	120 14.46	7.18	3.2	34/40	41	0.29	BA	N3	
24	21:41:36.78	47 36.27	120 13.99	4.88	1.9	20/22	81	0.21	BB	N3	
25	01:17:27.84	46 12.08	122 11.42	1.60	0.4	6/07	138	0.08	AC	S3	
25	11:00:59.68	46 51.13	121 45.67	3.16	0.3	6/11	92	0.18	BC	C3	
25	13:13:13.97	47 40.83	120 00.40	5.00	0.1	4/06	187	0.03	AD	N3	
25	18:01:51.62	46 30.65	122 27.30	18.83	0.3	9/13	190	0.04	AD	C3	
25	23:36:13.65	48 05.23	121 55.30	0.03*	0.9	8/11	123	0.30	BC	P3	
25	23:44:36.17	46 13.73	122 11.91	5.98	0.1	10/16	69	0.11	AA	S3	
26	01:45:57.81	46 32.49	122 23.67	18.46	0.5	18/24	173	0.11	AC	C3	
26	05:34:11.22	46 35.33	123 06.13	44.83	1.6	34/38	84	0.24	BA	P3	
26	14:43:01.81	46 52.06	121 53.65	7.64	0.0	5/09	171	0.14	AD	C3	
26	17:45:21.03	47 54.95	122 09.53	18.83	2.4	31/38	65	0.15	BB	P3	
26	20:06:15.68	46 53.06	121 44.26	0.03*	1.2	5/05	121	0.08	AD	C3	L
26	20:17:01.47	46 50.59	121 45.62	0.04*	-0.4	5/09	164	0.09	AD	C3	
26	22:59:05.10	49 23.54	119 58.11	0.02*	2.3	11/11	283	0.47	CD	C3	R
27	00:04:29.47	49 25.32	120 28.57	0.04#	1.7	12/12	260	0.68	DD	C3	R
27	06:39:54.91	48 19.99	121 55.29	0.05*	1.8	16/18	65	0.37	CC	P3	
27	09:30:03.71	46 16.34	122 12.17	5.90*	1.1	23/34	51	0.10	AA	S3	
27	10:01:10.77	48 18.92	121 58.24	7.66	0.7	5/07	151	0.19	BD	P3	
28	01:08:58.95	45 59.37	118 19.02	9.47	4.3	22/23	144	0.24	BC	E3	F
28	02:32:47.20	45 59.53	118 20.95	3.13	1.8	16/17	189	0.38	CD	E3	
28	07:18:54.65	46 52.94	121 44.91	0.03*	1.2	5/05	110	0.44	CD	C3	L
28	10:29:42.95	47 41.01	120 19.82	0.54	1.3	9/12	159	0.14	AC	N3	
28	10:45:34.41	46 00.10	118 23.09	0.02*	2.1	12/12	161	0.18	BC	E3	
28	10:53:13.94	48 22.75	122 09.76	14.70	0.5	5/08	227	0.13	AD	P3	
28	14:05:46.54	46 51.34	121 44.97	0.03*	1.5	5/05	161	0.07	AD	C3	L
29	09:17:49.51	46 44.17	121 30.10	5.78	0.3	8/14	232	0.09	AD	C3	
29	20:08:31.64	46 12.97	122 10.86	8.41	0.1	15/23	51	0.10	AA	S3	
29	21:01:34.23	46 52.93	121 42.98	0.02#	1.7	5/05	177	0.65	DD	C3	L
29	23:10:21.30	46 10.77	122 18.98	11.40	-0.1	11/14	95	0.08	AB	S3	
30	15:57:45.06	47 51.73	122 47.96	15.67	1.1	12/16	94	0.19	BB	P3	
30	20:45:57.12	46 12.12	122 11.03	0.65	0.8	12/16	76	0.10	AA	S3	
30	23:42:10.68	46 55.41	121 57.03	13.35	0.6	13/19	101	0.12	AB	C3	

Dec 1991

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	08:20:55.45	46 13.10	122 10.72	8.79	0.0	10/16	87	0.05	AA	S3	
1	14:47:56.95	49 14.14	119 33.36	0.04*	2.5	10/11	268	0.46	CD	N3	R
1	20:47:40.42	46 44.95	121 41.30	0.92	1.1	10/17	113	0.09	AB	C3	
2	05:32:01.29	46 49.61	121 40.04	0.96	1.3	5/05	232	0.13	BD	C3	L
2	06:53:15.74	46 11.77	122 11.91	6.40	-0.5	5/09	178	0.07	AD	S3	
2	06:53:28.22	46 11.76	122 11.10	6.75	0.2	8/15	130	0.10	AB	S3	
2	09:34:04.01	46 51.54	119 03.60	2.48	1.2	15/20	178	0.35	CC	E3	
2	19:05:04.48	46 11.75	122 11.57	0.04*	0.4	4/04	149	0.11	AD	S3	
2	22:32:07.23	46 02.97	122 11.34	1.13*	1.3	11/13	136	0.11	AC	S3	P
3	07:20:37.90	49 08.86	122 40.19	12.79	2.2	14/16	270	0.39	CD	P3	
3	08:34:36.04	46 42.41	122 06.28	20.94	0.5	15/23	155	0.08	AC	C3	
4	07:36:22.85	46 33.15	121 32.91	4.63	0.5	5/08	284	0.35	CD	C3	
4	20:06:50.16	49 09.71	120 36.76	37.47	1.8	6/06	266	0.43	DD	C3	R
4	22:38:58.14	45 19.48	121 11.76	27.50	1.8	13/14	69	0.88	DA	O0	
4	23:38:15.97	46 21.07	122 41.35	3.23	1.2	22/28	209	0.20	BD	C3	P
5	01:40:12.70	48 18.16	121 37.10	10.25	0.5	5/08	210	0.33	CD	P3	
5	02:59:45.40	46 50.59	121 43.69	0.04#	0.9	5/06	188	0.41	CD	C3	L
5	05:44:17.03	47 44.82	120 00.29	5.37	1.1	11/17	99	0.20	BB	N3	
5	11:19:59.64	46 53.24	121 48.21	0.41	1.7	5/05	218	0.74	DD	C3	L
5	22:03:07.29	49 08.37	119 41.64	0.02#	0.0	7/07	317	0.23	BD	N3	R

Dec 1991 cont'd

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
7	00:06:24.56	46 46.64	122 49.92	6.62	1.8	18/18	85	0.15	AC	P3	P
7	00:40:10.18	47 39.64	120 13.00	4.60	1.2	3/06	165	0.04	AD	N3	
7	06:43:19.85	46 50.18	121 37.99	19.88	0.1	5/07	247	0.37	DD	C3	
7	10:41:57.01	45 58.30	122 52.14	24.44	0.8	9/13	302	0.09	AD	C3	
8	06:35:49.39	46 52.09	121 41.88	14.08	1.5	5/07	198	0.62	DD	C3	L
8	09:43:02.36	46 32.27	122 23.15	20.92	0.3	11/16	176	0.11	AC	S3	
9	15:45:16.85	46 16.53	122 23.87	6.76	1.4	20/26	92	0.08	AB	S3	
9	16:17:05.32	46 16.57	122 23.63	7.06	1.8	22/31	91	0.10	AB	S3	
9	21:28:38.03	47 39.00	120 14.34	0.51	0.4	5/09	117	0.13	AD	N3	
10	11:44:49.94	47 58.03	121 53.52	13.70	-0.1	4/08	168	0.11	AD	P3	
10	16:43:10.01	47 09.23	122 57.19	0.03*	0.3	3/05	332	0.39	CD	P3	
10	23:09:16.88	46 43.78	122 47.69	6.42*	2.4	23/23	86	0.12	AC	P3	P
11	03:09:20.67	46 51.56	121 45.14	3.15	1.1	6/06	148	0.12	AC	C3	L
11	19:08:52.32	45 20.83	122 47.67	22.83	1.0	15/18	155	0.24	BC	O0	
12	00:26:53.56	47 58.10	121 54.31	10.13	1.1	4/07	191	0.08	AD	P3	
12	22:22:18.56	47 46.51	122 03.71	17.63	1.2	9/15	97	0.12	AB	P3	
13	11:47:45.37	46 51.42	121 54.26	4.74	1.8	18/27	107	0.12	AB	C3	
13	16:26:05.76	47 46.15	122 19.13	22.55	1.5	27/37	46	0.11	AA	P3	
13	18:00:40.78	47 46.13	122 18.87	22.33	0.8	18/23	58	0.08	AA	P3	
13	20:18:37.54	49 21.92	119 57.90	0.02*	2.2	11/14	265	0.43	CD	N3	R
14	00:24:32.26	45 50.75	122 30.81	7.70	1.1	13/18	277	0.23	BD	C3	P
14	00:53:44.34	46 50.83	121 45.07	2.27	-0.6	5/10	171	0.01	AD	C3	
14	02:51:30.70	46 52.44	121 53.45	6.15	0.6	8/13	165	0.12	AC	C3	
14	03:22:48.28	46 12.08	122 11.23	1.72	0.0	7/08	89	0.07	AB	S3	
14	06:19:12.86	46 56.41	120 22.52	3.53	1.3	22/24	65	0.24	BC	E3	
14	06:52:03.07	46 51.41	121 44.69	0.03*	1.7	5/05	168	0.58	DD	C3	L
14	07:57:41.79	46 52.25	121 43.87	0.02#	0.7	4/05	173	0.46	CD	C3	L
14	08:57:50.64	46 18.08	122 19.83	10.26	0.2	13/21	107	0.07	AB	S3	
14	10:09:52.04	46 18.13	122 19.98	10.20	0.1	12/15	108	0.06	AB	S3	
14	14:26:00.15	46 18.12	122 19.96	10.28	0.0	9/13	108	0.05	AB	S3	
15	01:45:55.19	46 10.64	122 18.81	11.75	0.5	16/27	56	0.08	AA	S3	
15	09:50:19.13	42 53.31	123 36.47	29.28	1.9	6/06	265	0.54	DD	O0	
15	22:14:53.12	45 59.67	118 19.73	7.98	3.3	17/17	196	0.19	CD	E3	F
16	04:15:25.27	46 52.55	121 45.01	1.26$	1.3	5/05	106	0.30	CD	C3	L
16	11:34:32.88	46 53.86	121 45.14	0.02*	1.4	4/04	194	0.48	CD	C3	L
16	23:46:50.28	46 12.08	122 11.07	2.01	0.7	10/12	85	0.07	AA	S3	
17	07:24:26.50	46 11.71	122 11.38	7.23	0.1	18/25	44	0.08	AA	S3	
17	20:18:24.54	47 38.14	121 57.04	22.75	1.3	14/18	114	0.15	BB	P3	
17	21:59:55.51	48 31.80	121 28.96	0.03*	0.9	5/06	187	0.27	BD	C3	
17	22:12:06.22	46 53.08	121 43.15	0.04#	1.1	4/04	173	0.58	DD	C3	L
17	22:47:09.22	46 12.28	122 10.86	0.04*	0.6	5/05	139	0.12	AD	S3	
17	22:55:57.12	46 40.58	120 35.60	6.85	0.7	5/09	125	0.17	BD	E3	
17	23:02:59.04	46 42.88	122 15.94	15.10	2.1	33/36	43	0.13	AA	C3	
17	23:59:27.97	48 21.96	122 02.28	0.03*	1.4	6/08	93	0.30	BC	P3	P
18	05:34:17.90	46 52.32	121 43.77	0.02#	1.3	5/05	173	0.40	CD	C3	L
18	08:06:22.50	47 25.95	122 46.56	2.06	1.9	21/22	93	0.26	BC	P3	
18	23:56:19.71	45 00.71	121 37.72	0.04*	2.0	5/06	193	0.15	BD	O0	P
19	05:32:13.56	46 56.37	120 22.33	3.43	1.4	25/26	45	0.30	BC	E3	
19	13:43:32.34	46 52.40	121 45.18	2.48	-0.1	4/05	171	0.07	AD	C3	
19	23:36:32.08	47 39.81	122 43.85	47.53	1.5	26/29	51	0.30	CA	P3	
20	07:39:39.44	46 30.77	122 25.76	19.19	0.5	22/28	99	0.10	AB	C3	
20	07:41:01.73	49 09.81	122 48.54	16.43$	1.3	8/09	296	0.27	CD	P3	
20	08:26:18.37	46 12.20	122 11.30	3.71	1.7	29/38	49	0.17	BA	S3	
20	09:41:10.82	46 11.92	122 11.69	2.55	-0.5	5/06	179	0.07	AD	S3	
20	09:41:14.97	46 12.08	122 12.63	3.62	0.2	12/18	61	0.20	BA	S3	
20	11:34:00.61	46 12.30	122 11.20	2.57	-0.3	5/06	209	0.08	AD	S3	
20	12:21:47.53	46 32.78	122 24.12	19.21	0.4	14/19	179	0.08	AC	C3	
20	14:59:42.20	46 03.76	122 26.15	17.84	0.9	15/21	249	0.14	AD	S3	
20	15:03:13.00	46 51.38	121 42.68	0.03*	1.6	6/06	125	0.41	CC	C3	L
20	18:16:39.40	46 12.14	122 11.90	5.02	0.0	7/08	146	0.18	BC	S3	
20	20:03:46.74	49 20.69	120 30.12	0.02*	2.1	15/16	247	0.66	DD	C3	R
20	21:31:14.64	46 08.22	122 10.68	1.84	1.3	24/29	88	0.13	AA	S3	P
20	23:17:45.25	46 12.39	122 11.35	1.70	0.2	4/05	214	0.00	AD	S3	
21	01:35:32.08	47 30.66	122 49.49	16.59	1.6	20/23	96	0.17	BB	P3	
21	01:54:07.26	47 30.78	122 48.85	1.84	1.5	17/17	145	0.23	BD	P3	

Dec 1991 cont'd

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
21	13:04:22.85	46 12.15	122 11.17	1.89	0.7	11/18	62	0.07	AA	S3	
21	13:45:28.24	46 50.56	121 45.71	0.03*	0.0	6/10	97	0.11	AC	C3	
21	13:53:58.81	46 52.06	121 44.83	0.02*	1.3	5/05	126	0.28	BD	C3	L
21	14:41:31.88	46 50.69	121 45.65	0.04*	1.4	5/05	161	0.08	AD	C3	
21	23:02:33.99	46 15.38	122 03.26	11.85	1.1	28/42	63	0.11	AA	S3	
22	19:49:17.61	46 51.05	121 45.05	2.33	-0.2	6/10	103	0.17	BC	C3	
22	22:28:00.62	46 45.64	121 55.27	4.38	1.0	18/26	99	0.09	AB	C3	
23	00:32:52.42	47 41.51	120 02.24	5.23	1.7	20/27	61	0.42	CB	N3	
23	11:17:59.73	47 41.38	120 05.10	5.76	0.9	6/09	107	0.14	AC	N3	
23	19:10:13.95	46 50.99	121 44.22	0.03*	0.9	5/05	179	0.23	BD	C3	L
23	19:56:20.90	46 15.14	122 03.12	11.63	1.9	33/44	50	0.09	AA	S3	
23	22:24:11.34	46 12.10	122 11.38	1.74	0.4	8/11	91	0.06	AB	S3	
23	23:29:59.29	46 11.94	122 11.11	0.05*	0.8	7/09	90	0.07	AB	S3	
23	23:40:25.65	49 16.46	120 01.69	0.02*	2.2	14/14	250	0.43	CD	N3	R
24	01:49:55.86	47 31.60	122 14.53	0.05*	0.3	9/13	123	0.26	BB	P3	
24	02:16:36.35	45 16.65	122 44.07	29.32	1.1	17/20	148	0.23	BC	O0	
24	06:39:22.65	46 51.53	121 44.79	0.02*	1.4	7/07	98	0.54	DB	C3	L
24	12:18:57.36	46 55.95	120 19.78	3.20	2.0	36/37	40	0.23	BC	E3	
24	16:31:23.15	46 52.65	121 44.41	0.02*	1.0	4/04	167	0.51	DD	C3	L
24	17:02:01.52	46 45.49	124 01.74	31.99	1.6	19/22	189	0.63	DD	P3	
24	20:33:15.54	47 08.44	119 54.41	0.04*	1.3	17/19	79	0.25	BC	N3	
25	00:28:26.01	48 22.15	123 21.29	16.71*	2.2	18/21	144	0.21	BC	P3	
25	05:22:18.14	47 48.40	122 23.33	19.44	1.1	13/15	66	0.15	BA	P3	
25	06:08:08.17	46 15.07	122 03.19	12.49	0.2	13/20	70	0.11	AA	S3	
25	09:02:35.76	46 53.57	121 43.95	0.03*	1.3	4/04	176	0.40	CD	C3	
25	17:08:53.18	46 15.22	122 03.64	13.12	0.2	14/22	68	0.09	AA	S3	
25	22:12:53.15	46 48.67	121 55.52	11.51	2.1	31/40	40	0.10	AA	C3	
26	03:42:37.04	46 12.14	122 11.67	2.30	-0.2	6/06	144	0.05	AC	S3	
26	08:40:51.76	46 51.32	121 43.19	4.99	1.1	5/05	188	0.05	AD	C3	L
26	09:49:04.92	47 41.13	120 04.18	5.79	1.9	18/24	89	0.21	BB	N3	
27	17:19:00.77	46 51.79	121 40.74	0.04*	1.7	6/06	213	0.78	DD	C3	L
28	00:51:54.38	46 52.77	121 45.49	0.03#	2.4	6/06	110	1.50	DC	C3	L
28	01:40:52.79	46 53.37	121 46.45	1.02	0.7	5/05	122	0.33	CD	C3	L
28	08:42:43.84	46 52.74	121 44.62	0.02*	1.3	4/04	170	0.29	BD	C3	L
28	10:15:32.23	46 51.50	121 45.81	0.29	1.0	13/18	58	0.15	AA	C3	
28	11:23:41.73	46 52.35	121 44.42	4.46	0.6	5/05	101	0.12	BD	C3	L
28	14:34:55.32	46 51.03	121 45.13	2.87	-0.1	6/12	101	0.27	BC	C3	
29	02:07:32.16	46 46.94	121 58.95	8.79	0.4	9/15	135	0.12	AB	C3	
29	03:08:04.14	46 50.98	121 45.17	2.39	-0.1	6/10	101	0.21	BC	C3	
29	03:41.20.37	46 52.05	121 47.21	0.05*	0.4	5/05	106	0.08	AD	C3	L
29	05:54:39.93	48 16.74	122 06.25	13.61	0.4	6/09	189	0.16	BD	P3	
29	08:37:54.83	46 50.39	121 45.65	0.78$	0.1	6/11	167	0.06	CC	C3	
29	08:38:17.60	46 50.60	121 46.05	0.48	0.5	7/12	91	0.08	AB	C3	
29	08:38:37.29	46 50.39	121 45.56	0.93$	-0.3	5/08	168	0.08	CD	C3	
29	08:38:44.92	46 50.34	121 45.87	0.12	-0.2	5/09	163	0.12	AD	C3	
29	08:39:06.75	46 50.48	121 46.09	0.03*	-0.1	7/11	92	0.08	AB	C3	
29	08:39:10.87	46 50.31	121 45.63	1.05	0.5	6/09	168	0.04	AC	C3	
29	08:40:43.25	46 50.45	121 45.50	1.70	-0.3	5/09	169	0.06	AD	C3	
29	08:40:51.62	46 50.43	121 45.90	0.83	0.5	10/14	65	0.14	AA	C3	
29	08:41:07.03	46 50.49	121 45.99	0.52	0.5	6/11	93	0.09	AC	C3	
29	08:49:00.03	46 50.54	121 46.50	0.06	-0.3	6/09	89	0.13	AC	C3	
29	09:07:20.94	46 50.29	121 45.74	0.33	-0.4	6/10	100	0.12	AC	C3	
29	09:51:51.41	46 15.18	122 02.76	12.29	0.3	14/21	72	0.12	AA	S3	
29	12:39:40.63	46 50.12	121 39.30	0.73	1.4	5/05	236	0.35	CD	C3	
29	16:18:19.93	47 48.07	122 45.96	15.58*	1.4	17/21	94	0.17	BB	P3	
30	02:20:16.51	46 51.31	121 45.50	0.57	0.6	7/11	94	0.12	AB	C3	
30	06:13:40.69	47 41.44	120 19.40	1.46	1.1	4/06	228	0.07	BD	N3	
30	23:15:03.14	46 44.15	122 47.09	8.65	2.9	10/10	69	0.14	AC	P3	P
31	07:42:34.96	46 51.98	121 46.64	0.04*	0.5	5/05	109	0.07	AD	C3	
31	08:55:05.12	46 41.95	121 46.13	6.00	0.3	8/13	108	0.07	AB	C3	
31	09:04:29.37	46 51.79	121 45.60	1.44$	1.4	6/06	99	0.19	CC	C3	L
31	09:40:09.87	46 48.18	121 56.17	7.76	-0.1	5/10	228	0.14	AD	C3	
31	22:50:42.79	46 52.04	121 43.55	0.02#	1.0	5/05	178	0.21	BD	C3	L
31	23:12:51.50	46 43.74	122 47.26	6.09*	2.7	23/23	78	0.10	AC	P3	P

QUARTERLY NETWORK REPORT 92-A

on

Seismicity of Washington and Northern Oregon

January 1 through March 31, 1992

Geophysics Program

University of Washington

Seattle, Washington

This report is prepared as a preliminary description of the seismic activity in the state of Washington and northern Oregon. Information contained in this report should be considered preliminary, and not cited for publication. Seismic network operation in Washington and northern Oregon is supported by the following contracts:

U.S. Geological Survey
Joint Operating Agreement 14-08-0001-A0622
and
Joint Operating Agreement 14-08-0001-A0623

and

Westinghouse Hanford Company
Contract PMM-RJU-505

CONTENTS

FIGURES

TABLES

INTRODUCTION

This is the first quarterly report of 1992 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. Annual reports covering seismicity in Washington since 1969 are available from the U.W. Geophysics Program.

This quarterly report discusses network operations, seismicity of the region, and unusual events or findings. This report is 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. Fig. 1 is a map view of seismograph stations currently in operation.

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. Fig. 1 shows a map view of stations operating during the quarter.

There was very little activity related to network operations this quarter, with only only one new station installed, and routine maintenance at a minimum, as it is every winter. Station LCW (Lucas Creek, Wa.) was installed on March 27, and replaces station APW (Alpha Peak, Wa) which was abandoned when a nearby quarry began production and the site became too noisy. Station LCW lies east of the towns of Centralia and Chehalis, Wa.

OUTREACH ACTIVITIES

In addition to monitoring the earthquake activity for Washington and much of Oregon, there are a number of projects conducted each quarter which are related to the operation of the Washington Regional Seismic Network. Beginning with this quarterly report, we will outline some of the major topics and activities which have been requested by the community, or are current areas of research conducted by the staff of the Geophysics Program.

In early March we installed a new voice mail phone system which allows callers to automatically access various types of recorded information. The phone number for this service is (206) 543-7010. A summary of its use in March shows 717 outside calls. 49% of the callers were interested in current seismic event information which is recorded on a daily basis, 10% of the callers wanted more extensive historical and background seismic activity information, and the remaining 41% chose to ring through directly or leave voicemail.

Specific outreach activities are performed primarily by Chris Jonientz-Trisler, and include lab tours and guest lectures. This quarter ten seismology lab tours took place, including four tours for elementary through middle school students and teachers, two tours for prospective geophysics graduate students, one tour for foreign University of Washington students, one tour for the U. W. Space Grant Program for high school students, and two tours for emergency preparedness officials from Bangor Submarine Base and Cowlitz County. Five earthquake awareness outside presentations were made, some in conjunction with nationally recognized Mothers for H.E.L.P., to Kent School District, Mercer Island School District, Naval Base Seattle, North Thurston School District and Seward Elementary School. The intent of the presentation given to naval personnel was to educate several dozen navy and coast guard emergency officers from several western states to the mechanisms and effects of earthquakes in order to assist them in preparedness and to help them plan an effective earthquake drill for several of their western Washington facilities in the fall. Other activities included a lecture on volcano processes, given to the Burke Memorial Washington State Museum staff, and four meetings with the Naval Emergency Coordinator to research, design and review a realistic local earthquake scenario that will allow the Navy and Coast Guard to more effectively prepare personnel and facilities to deal with the next major earthquake in this region. Finally, Anthony Qamar gave a presentation to Seattle City Light personnel on earthquake hazards to electrical systems in the greater Puget Sound area and also a lecture on earthquake hazards to the Food and Drug Administration.

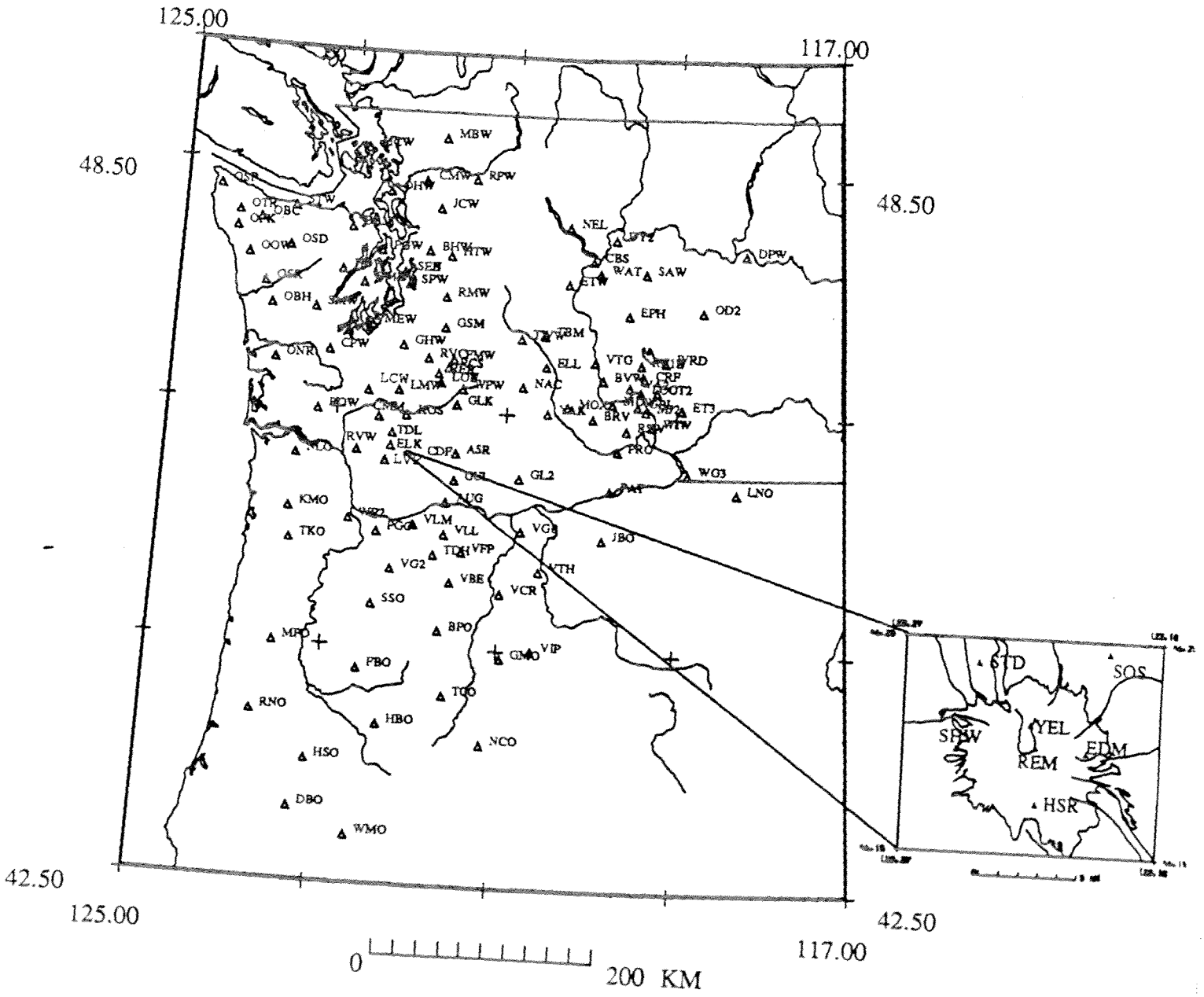

Figure 1: Stations operating at the end of the First Quarter, 1992.

TABLE 1
Station Outages 1st quarter 1992

Station	Outage Dates	Comments
APW	Whole period	Dead, pulled and replaced with LCW
CDF	Jan 5 to Jan 8	Dead
ELL	Jan 26 to March 6	Dead
GLK	Whole Period	Dead
JUN	Jan 5-End	intermittent xtalk with CDF
LCW	Beginning to March 27	New station
OBH	Whole Period	Intermittent to Jan 5, dead
OSD	Beginning to January 8	Dead
REM	Jan 12 to Jan 15	Dead
SMW	Beginning to March 15	Dead
TBM	Jan 26-March 6	Dead
TWW	Jan 26 to March 6	Dead
YAK	Jan 26-March 6	Dead
YEL	Beginning to Jan 10	Dead

STATIONS USED FOR LOCATION OF EVENTS

Table 2 lists stations used in locating seismic events in Washington and Oregon. Stations marked by an asterisk (*) were supported by USGS joint operating agreement 14-08-0001-A0622. Stations marked by (%) were supported by USGS contract 14-08-0001-A0623. (+) indicates support under Westinghouse Hanford Company Contract PMM-RJU-505. All other stations were supported from other sources.

The first column in the table gives the 3-letter station designator. This is followed by a symbol designating the funding agency, station north latitude and west longitude (in degrees, minutes and seconds), station elevation in km, and comments indicating landmarks for which stations were named.

TABLE 2

Stations Operating at the End of the First Quarter 1992

STA	F	LAT	LONG	EL	NAME
APW	*	46 39 06.0	122 38 51.0	0.457	Alpha Peak
ASR	%	46 09 02.4	121 35 33.6	1.280	Mt. Adams - Stagman Ridge
AUG	%	45 44 10.0	121 40 50.0	0.865	Augspurger Mtn
BHW	*	47 50 12.6	122 01 55.8	0.198	Bald Hill
BLN	*	48 00 26.5	122 58 18.6	0.585	Blyn Mt.
BOW	*	46 28 30.0	123 13 41.0	0.870	Boistfort Mt.
BPO	%	44 39 06.9	121 41 19.2	1.957	Bald Peter, Oregon
BRV	+	46 29 07.2	119 59 29.4	0.925	Black Rock Valley
BVW	+	46 48 37.8	119 52 54.1	0.707	Beverly
CBS	+	47 48 16.7	120 02 27.6	1.073	Chelan Butte, South
CDF	%	46 06 58.2	122 02 51.0	0.780	Cedar Flats
CMM	%	46 26 07.0	122 30 21.0	0.620	Crazy Man Mt.
CMW	*	48 25 25.3	122 07 08.4	1.190	Cultus Mtns.
COW	%	46 29 27.6	122 00 43.6	0.305	Cowlitz River
CPW	*	46 58 25.8	123 08 10.8	0.792	Capitol Peak
CRF	+	46 49 30.6	119 23 18.0	0.260	Corfu
DBO	%	43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon
DPW	+	47 52 14.3	118 12 10.2	0.892	Davenport
DY2	+	47 59 06.9	119 46 13.0	0.884	Dyer Hill 2
EDM		46 11 50.4	122 09 00.0	1.609	East Dome, Mt. St. Helens
ELK	%	46 18 20.0	122 20 27.0	1.270	Elk Rock
ELL	+	46 54 35.0	120 34 06.0	0.805	Ellensburg
EPH	+	47 21 12.8	119 35 46.2	0.628	Ephrata
ET3	+	46 34 37.0	118 56 11.0	0.305	Eltopia
ETW	+	47 36 16.2	120 19 51.6	1.475	Entiat
FBO	%	44 18 35.6	122 34 40.2	1.080	Farmers Butte, Oregon
FL2	%	46 11 47.0	122 21 01.0	1.378	Flat Top 2
FMW	*	46 55 54.0	121 40 19.2	1.890	Mt. Fremont

continued

STA	F	LAT	LONG	EL	NAME
GBL	+	46 35 51.6	119 27 35.4	0.330	Gable Mountain
GHW	*	47 02 30.0	122 16 21.0	0.268	Garrison Hill
GL2	+	45 57 35.0	120 49 22.5	1.000	Goldendale
GLK	%	46 33 50.2	121 36 30.7	1.320	Glacier Lake
GMO	%	44 26 20.8	120 57 22.3	1.689	Grizzly Mountain, Oregon
GMW	*	47 32 52.5	122 47 10.8	0.506	Gold Mt.
GRO	%	45 21 04.5	123 39 43.0	0.945	Grindstone Mt., Oregon
GSM	*	47 12 11.4	121 47 40.2	1.305	Grass Mt.
GUL	%	45 55 27.0	121 35 44.0	1.189	Guler Mt.
HBO	%	43 50 39.5	122 19 11.9	1.615	Huckleberry Mt., Oregon
HDW	*	47 38 54.6	123 03 15.2	1.006	Hoodsport
HSO	%	43 31 33.0	123 05 24.0	1.020	Harness Mountain, Oregon
HSR	%	46 10 22.2	122 10 58.2	1.774	South Ridge, Mt. St. Helens
HTW	*	47 48 12.5	121 46 08.6	0.829	Haystack Lookout
JBO	%	45 27 41.7	119 50 13.3	0.645	Jordan Butte, Oregon
JCW	*	48 11 36.6	121 55 46.2	0.616	Jim Creek
JUN	%	46 08 48.0	122 09 10.8	1.049	June Lake
KMO	%	45 38 07.8	123 29 22.2	0.975	Kings Mt., Oregon
KOS	%	46 27 40.8	122 11 25.8	0.828	Kosmos
LCW	*	46 40 14.4	122 42 02.8	0.396	Lucas Creek
LMW	*	46 40 04.8	122 17 28.8	1.195	Ladd Mt.
LNO	+	45 52 15.8	118 17 06.0	0.768	Lincton Mt., Oregon
LOC	+	46 43 04.8	119 25 54.6	0.201	Rohay Station
LO2		46 45 00.0	121 48 36.0	0.853	Longmire
LON		46 45 00.0	121 48 36.0	0.853	Longmire (DWWSSN)
LVP	%	46 04 06.0	122 24 30.0	1.170	Lakeview Peak
MBW	*	48 47 02.4	121 53 58.8	1.676	Mt. Baker
MCW	*	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MDW	+	46 36 48.0	119 45 39.0	0.330	Midway
MEW	*	47 12 07.0	122 38 45.0	0.097	McNeil Island
MJ2	+	46 33 28.0	119 21 50.0	0.150	Rockwell Station
MOX	+	46 34 38.0	120 17 35.0	0.540	Moxie City
MPO	%	44 30 17.4	123 33 00.6	1.249	Mary's Peak, Oregon
MTM	%	46 01 31.8	122 12 42.0	1.121	Mt. Mitchell
NAC	+	46 44 03.8	120 49 33.2	0.738	Naches
NCO	%	43 42 18.2	121 08 06.0	1.908	Newberry Crater, Oregon
NEL	+	48 04 41.8	120 20 17.7	1.490	Nelson Butte
NLO	*	46 05 18.0	123 27 00.0	0.900	Nicolai Mt., Oregon
OBC	%	48 02 07.1	124 04 39.0	0.938	Olympics - Bonidu Creek
OBH	%	47 19 34.5	123 51 57.0	0.383	Olympics - Burnt Hill
OD2	+	47 23 27.6	118 42 38.4	0.590	Odessa
OFK	%	47 57 00.0	124 21 28.1	0.134	Olympics - Forks
OHW	*	48 19 24.0	122 31 54.6	0.054	Oak Harbor
ONR	%	46 52 37.5	123 46 16.5	0.257	Olympics - North River
OOW	%	47 44 12.0	124 11 22.0	0.743	Octopus West
OSD	*	47 49 15.0	123 42 06.0	2.010	Olympics - Snow Dome
OSP	%	48 17 05.6	124 35 23.3	0.585	Olympics - Sooes Peak
OSR	%	47 30 20.3	123 57 42.0	0.815	Olympics Salmon Ridge
OT2	+	46 43 17.0	119 14 05.0	-	Othello
OTR	%	48 05 00.0	124 20 39.0	0.712	Olympics - Tyee Ridge
PAT	+	45 52 50.1	119 45 40.1	0.300	Paterson

continued

STA	F	LAT	LONG	EL	NAME
PGO	%	45 28 00.0	122 27 10.0	0.237	Gresham, Oregon
PGW	*	47 49 18.8	122 35 57.7	0.122	Port Gamble
PRO	+	46 12 45.6	119 41 09.0	0.552	Prosser
RC1		46 56 60.0	119 26 00.0	0.500	Royal City (3-component)
RCS		46 52 15.6	121 43 52.0	2.877	Mt. Rainier, Camp Schurman
REM		46 11 57.0	122 11 03.0	2.102	Rembrandt (Dome station)
RER		46 49 09.2	121 50 27.3	1.756	Mt. Rainier, Emerald Ridge
RMW	*	47 27 34.9	121 48 19.2	1.024	Rattlesnake Mt. (West)
RNO	%	43 54 44.0	123 44 26.0	0.875	Roman Nose, Oregon
RPW	*	48 26 54.0	121 30 49.0	0.850	Rockport
RSW	+	46 23 28.2	119 35 19.2	1.037	Rattlesnake Mt. (East)
RVC	%	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek
RVW	*	46 08 58.2	122 44 37.2	0.460	Rose Valley
SAW	+	47 42 06.0	119 24 03.6	0.690	St. Andrews
SEA		47 39 18.0	122 18 30.0	0.030	Seattle (Wood Anderson)
SEE		47 39 18.0	122 18 30.0	0.030	Seattle Pseudo-WA (E)
SEN		47 39 18.0	122 18 30.0	0.030	Seattle Pseudo-WA (N)
SHW	*	46 11 33.0	122 14 12.0	1.423	Mt. St. Helens
SMW	*	47 19 10.2	123 20 30.0	0.840	South Mt.
SOS	%	46 14 38.5	122 08 12.0	1.270	Source of Smith Creek
SPW	*	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle
SSO	%	44 51 21.6	122 27 37.8	1.242	Sweet Springs, Oregon
STD	%	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
STW	*	48 09 02.9	123 40 13.1	0.308	Striped Peak
TBM	+	47 10 10.1	120 35 54.0	1.064	Table Mt.
TCO	%	44 06 27.0	121 36 00.0	1.975	Three Creek Meadows, Oregon
TDH	%	45 17 23.4	121 47 25.2	1.541	Tom,Dick,Harry Mt., Oregon
TDL	%	46 21 03.0	122 12 57.0	1.400	Tradedollar Lake
TKO	%	45 22 16.7	123 27 14.0	1.024	Trask Mtn, Oregon
TWW	+	47 08 17.2	120 52 04.5	1.046	Teanaway
VBE	%	45 03 37.2	121 35 12.6	1.544	Beaver Butte, Oregon
VCR	%	44 58 58.2	120 59 17.3	1.015	Criterion Ridge, Oregon
VFP	%	45 19 05.0	121 27 54.3	1.716	Flag Point, Oregon
VG2	%	45 09 20.0	122 16 15.0	0.823	Goat Mt., Oregon
VGB	%	45 30 56.4	120 46 39.0	0.729	Gordon Butte, Oregon
VIP	%	44 30 29.4	120 37 07.8	1.731	Ingram Pt., Oregon
VLL	%	45 27 48.0	121 40 45.0	1.195	Laurance Lk., Oregon
VLM	%	45 32 18.6	122 02 21.0	1.150	Little Larch, Oregon
VTG	+	46 57 28.8	119 59 14.4	0.208	Vantage
VTH	%	45 10 52.2	120 33 40.8	0.773	The Trough, Oregon
WA2	+	46 45 24.2	119 33 45.5	0.230	Wahluke Slope
WAT	+	47 41 55.0	119 57 15.0	0.900	Waterville
WG3	+	46 01 43.0	118 51 24.0	0.480	Wallula Gap
WIW	+	46 25 48.8	119 17 13.4	0.130	Wooded Island
WMO	%	42 54 10.0	122 35 31.0	1.860	Whale Back Mt., Oregon
WP2	%	45 33 57.2	122 47 06.9	0.341	West Portland, Oregon
WPW	%	46 41 53.4	121 32 48.0	1.250	White Pass
WRD	+	46 58 11.4	119 08 36.0	0.378	Warden
YAK	+	46 31 15.8	120 31 45.2	0.619	Yakima
YEL		46 12 35.0	122 11 16.0	1.750	Yellow Rock, Mt. St. Helens

EARTHQUAKE DATA

There were 772 events processed by the University of Washington digital recording seismic network between January 1 and March 31, 1991. Locations were determined for 568 of these in Washington and Oregon; 475 of these were classified as earthquakes and 93 as known or suspected blasts. The remaining 295 processed events include teleseisms (97 events), regional events outside the U. W. network (115), and unlocated events within the U. W. network. Unlocated events within the U.W. network include very small earthquakes and some known blasts. For example, only a few of the frequent mine blasts at Centralia are routinely processed.

Table 3 is the catalog of earthquakes and blasts located within the network for this quarter. Fig. 2 shows all earthquakes with magnitude greater than or equal to 0.0 ($M_c \geq 0.$) Fig. 3 shows blasts and probable blasts ($M_c \geq 0.$) Fig. 4 shows earthquakes located at Mt. Rainier ($M_c \geq 0$). Fig. 5 shows earthquakes located at Mt. St. Helens ($M_c \geq 0$).

Western Washington and Oregon

During the first quarter of 1992, 371 earthquakes were located between 42.5° and 49.5° north latitude and between 121° and 125° west longitude. Most of these occurred at depths less than 30 km with, as usual, a small number of earthquakes in the Puget Sound lowland and near the Olympic Peninsula at depths greater than 30 km.

There were seven earthquakes reported felt in western Washington and Oregon this quarter. The first event occurred on January 18 approximately 19 km. southwest of Bremerton, Wa. at a depth of 14 km, and was a $M_c = 3.1$ event. It was reported felt on Vashon Island, in Port Orchard, Gig Harbor, and Bremerton. There were no reports of damage, and most individual reports included the sensation of minor ground shaking. The second event occurred on January 20, with $M_c = 3.1$ and a depth of 11 km., but was centered 14 km north of Arlington, Wa. Reports came in from only Arlington that residents there felt it. The largest event of the quarter occurred on March 13 and was centered near Smith Island, Wa, just west of Oak Harbor on Whidbey Island. It was a $M_c = 3.5$ event at 18 km depth, and was felt in Victoria, B.C., Port Angeles, Oak Harbor, and the San Juan Islands, but did not cause any damage.

On March 15, an earthquake occurred 25 km northwest of Longview, Wa., and had a magnitude of M_c = 3.0, at a depth of 28 km. There were some interesting aspects to this earthquake, in that there were more than a few reports of hearing an explosion preceeding the ground shaking. This is not uncommon when the earthquake has a very shallow source, but since this occurred nearly 17 miles deep, it seems noteworthy. It was also reported that lightweight figurines were knocked over in the town of Astoria, Oregon, which is within 40 km. of the epicenter. This wasn't the only earthquake to have been felt in Oregon. On March 24, a M_c = 2.9 earthquake occurred near Springfield, Oregon, with a shallow depth (< 3 km). Oregon Emergency Management agency reported that two felt reports were all that came in shortly after the event, and both were from Springfield.

Closer to Seattle, an earthquake with magnitude M_c = 3.2 occurred in the early evening of March 28 (March 29 UTC) and was centered near the town of Bellevue, Wa. People reported feeling it from Juanita, N. Edmonds, Kirkland, Bothell, Redmond, and even as far east as Duvall, Wa. All these areas are within 40 km of Seattle, Wa. The greatest sensation of ground motion was reported around the north end of Lake Washington. Because of the proximity to a large population center, and the time of day, there were many felt-reports, more than one would normally expect from a minor earthquake.

Eastern Washington and Oregon

During this quarter, 104 earthquakes were located in Eastern Washington. One was felt, occurring on January 24, and centered near the town of Entiat, Wa. This had a M_c = 3.4 and located 7 km east of Entiat, at a depth of 7 km. We received only three calls, but the earthquake was reported felt in Entiat, Chelan, and Manson. Windows reportedly shook, but there was no damage. Entiat is normally seismically active, with one to a few dozen earthquakes occurring there each quarter.

Mount Rainier Area

There were 135 events in the region near Mt. Rainier, as seen in Fig. 5. Of these, 17 were located in what is called the 'western zone', a north-south trending lineation of seismicity approximately 15 km west of the summit of Mt. Rainier. The rest were a combination of tectonic (53) and surficial events (70), with epicenters near the summit. The remaining events were scattered around the cone of Rainier as seen in

Fig. 5.

Activity at Mt. Rainier includes surface events (avalanches, ice quakes, etc.) and tectonic earthquakes. Earthquakes in our catalog flagged with type "L" (for low frequency), are generally surficial events. Shallow tectonic earthquakes have a higher frequency and a different source. The number of events in close proximity to the cone of Mt. Rainier varies over the course of the year, since the source of much of the shallow surface-type activity is presumably ice movement or avalanching, which is seasonal in nature.

Mount St. Helens Area

56 events were located at Mt. St. Helens this quarter. The largest event had a magnitude of M_c = 1.2 and occurred on February 12. Of the total, 12 earthquakes were deeper than 4 km. The ratio between the number of 'deeper' and 'shallower' events continues to fluctuate, but there seems to be no particular importance associated with this observation during the last few years.

Other Earthquake Information

In addition to this publication, other information is available from various agencies and through computer connections. A non-interactive login account exists on the main University of Washington Geophysics Program computer called "quake" with password, "quake" which contains the latest information about earthquakes world-wide (from the National Earthquake Information Center) and from the Pacific Northwest (from the Washington Regional Seismograph Network). To receive this information by phone, dial (206) 685-0889 with either a 1200 or 2400 baud modem or use "finger quake@geophys.washington.edu" on the InterNet. Also, automatic computer generated alert messages are sent by E-Mail or by FAX to those government or research institutions needing such information. A complete listing of events and analyzed phases is sent by E-Mail to regional seismograph network operators within a few days of real time for events of interest to them, as well. Anyone interested in receiving such information should contact, via E-Mail rick@geophys.washington.edu.

Earthquake information in the quarterlies is published in final form by the Washington State Department of Natural Resources as information circulars entitled "Earthquake Hypocenters in Washington and

Northern Oregon" covering the period 1970-1986 (see circulars #53,56,64-66,72,79,82-84). A catalog covering earthquakes in1987-1989 is in preparation. These circulars, plus circular #85, "Washington State Earthquake Hazards", are available from Washington Dept. of Natural Resources, Division of Geology and Earth Resources, Mail Stop PY-12, Olympia, Wa. 98504, or by telephone at (206) 459-6372.

Other regional agencies from which information may be obtained include the Geological Survey of Canada, which provides a monthly summary of Canadian earthquakes, and they can be reached at the Pacific Geoscience Centre, Sidney, B.C. Their fax number is (604) 363-6565. For information about Northern California earthquakes, one may obtain the weekly "Seismicity Reports for Northern California", outlining significant events and observations for Northern California only. You can contact the United States Geological Survey, 345 Middlefield Rd, MS-977, Menlo Park, Ca, 94025, attn: Steve Walter. Similarly, for Southern California information, there is a "Weekly Earthquake Report for Southern California". This is prepared by Kate Hutton and Lucy Jones, c/o USGS, California Institute of Technology, Pasadena, Ca.

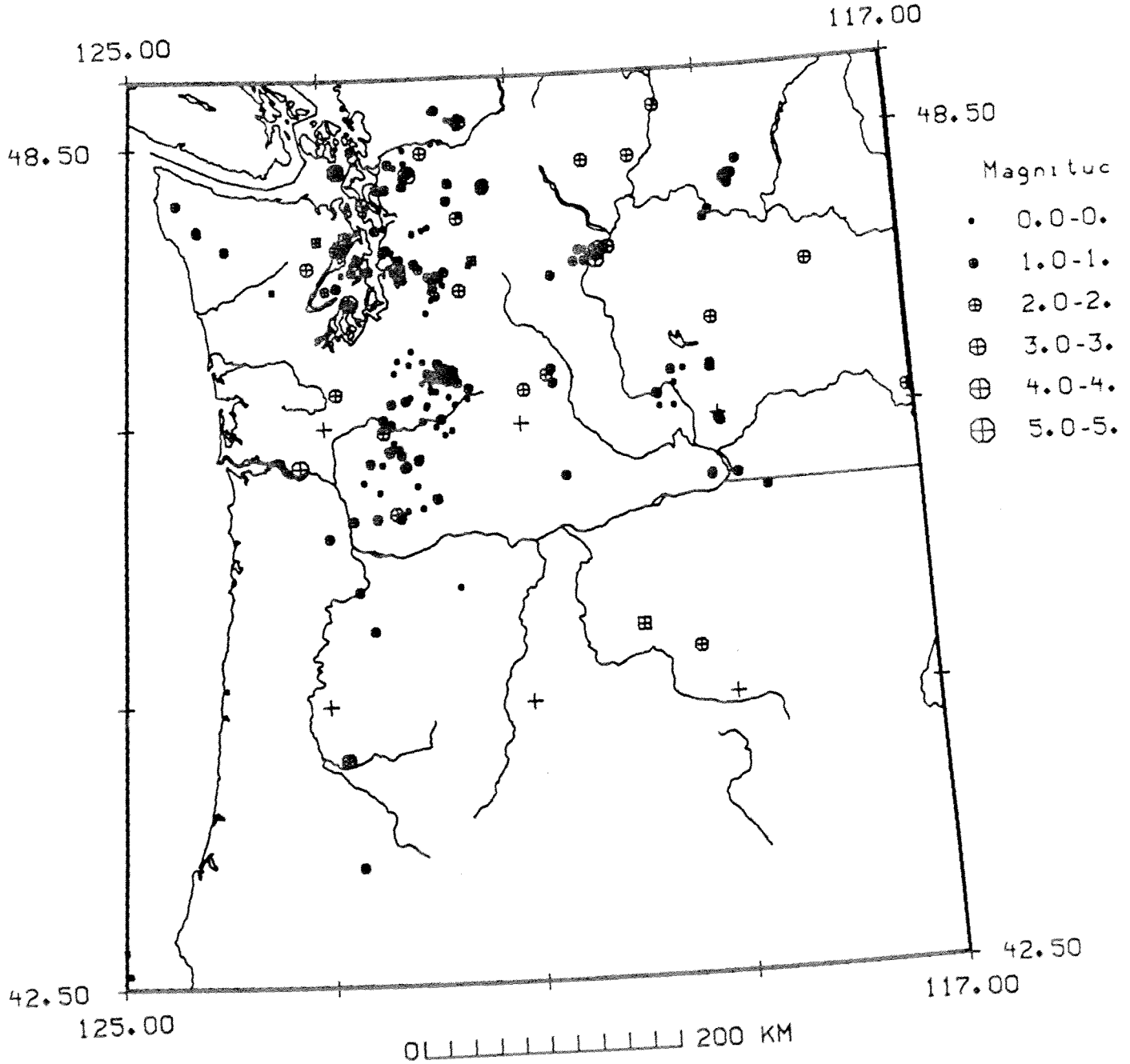

Figure 2: Earthquakes located in Washington and Oregon with magnitudes greater than 1.0, first quarter, 1992. A square symbol indicates that an event located with a depth greater than or equal to 30 km.

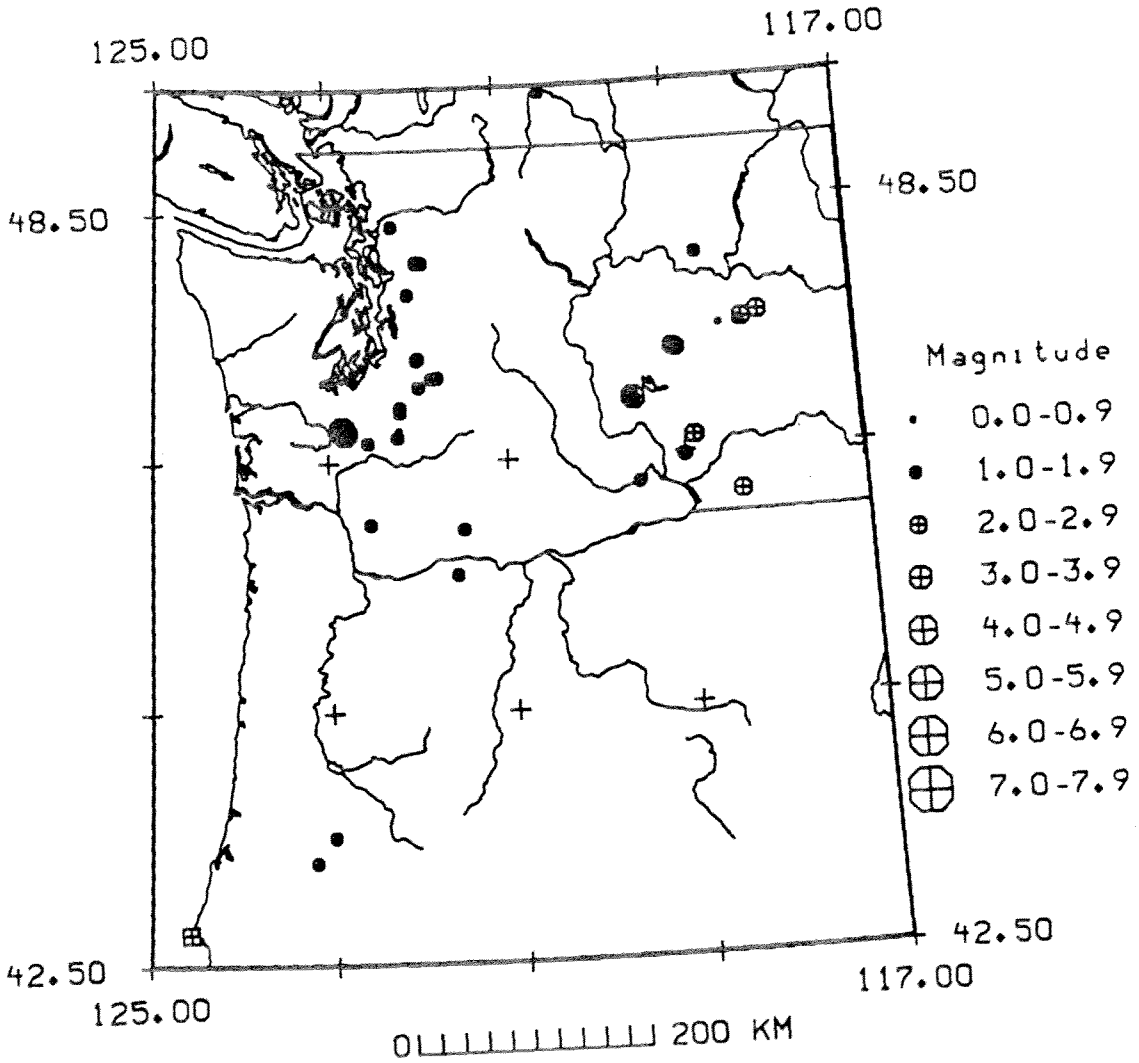

Figure 3: Blasts and Probable Blasts, First Quarter, 1992.

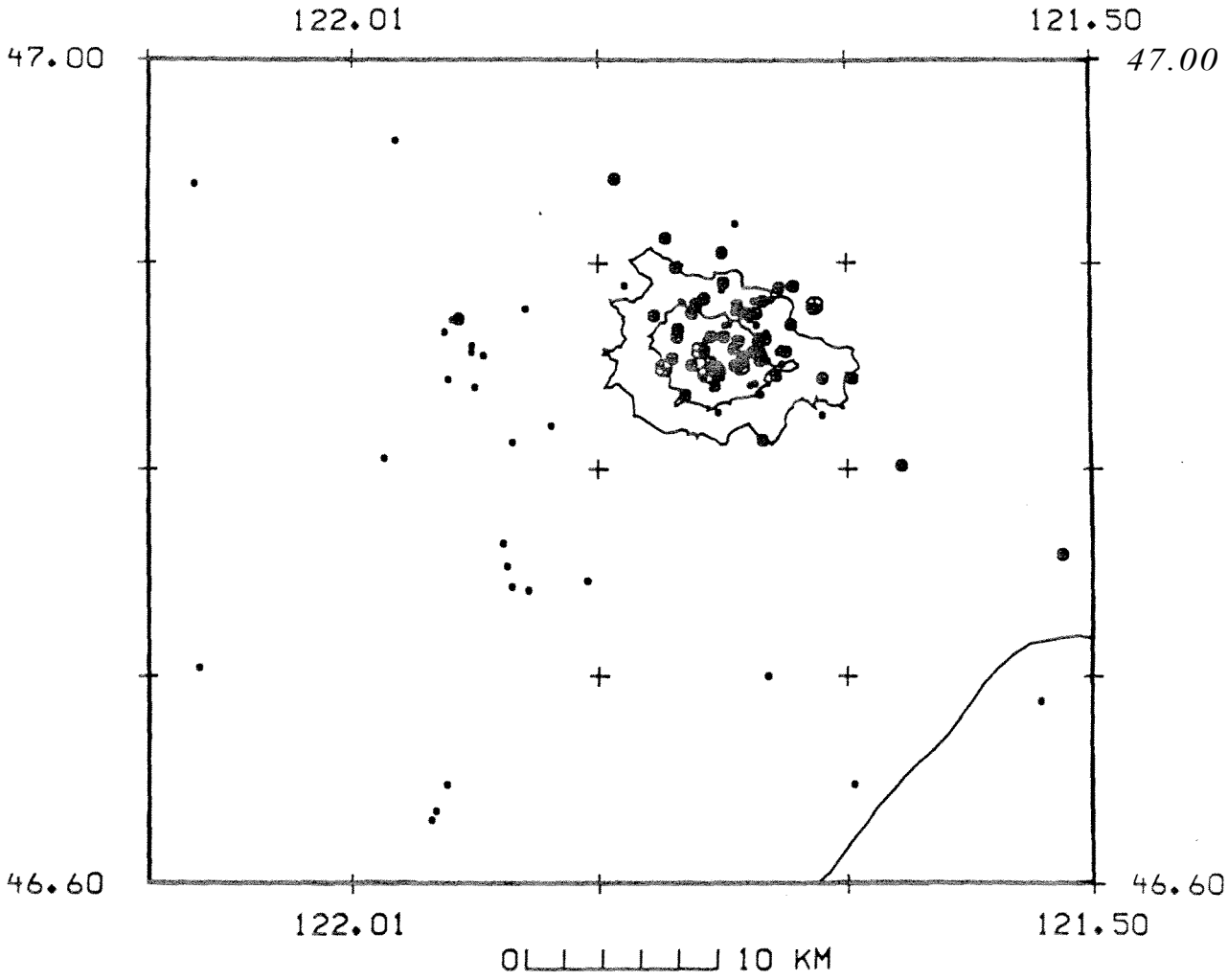

Figure 4: Earthquakes located in the Mt. Rainier area first quarter, 1992. All events are greater than 0.0. Inner contour is 10,000 foot contour, and the outer is the 7,500 foot contour.

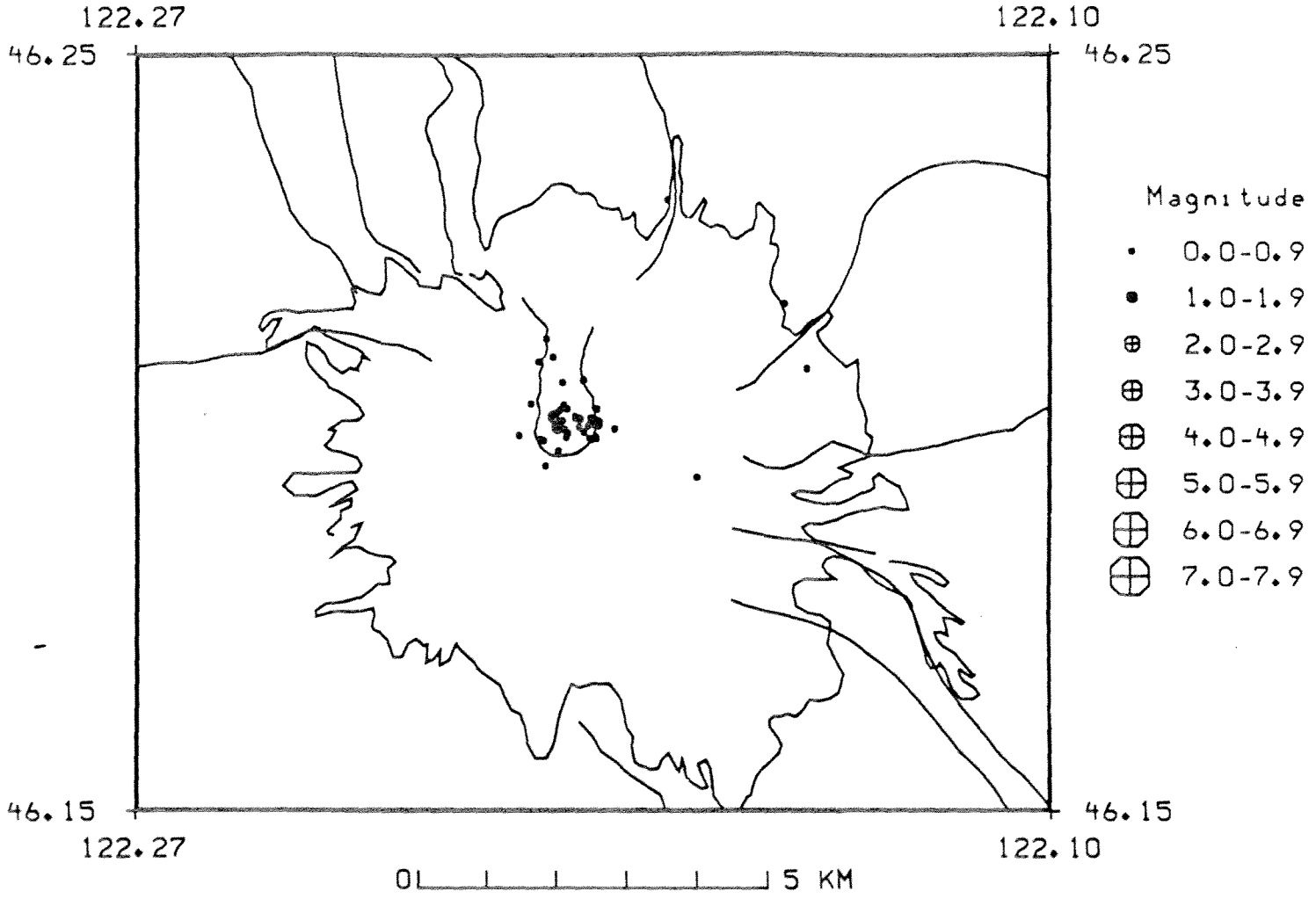

Figure 5: Earthquakes located in the Mt. St. Helens area during the first quarter, 1992. All events were shallower than 30 km.

QUARTERLY NETWORK REPORT 92-B

on

Seismicity of Washington and Northern Oregon

April 1 through June 30, 1992

Geophysics Program

University of Washington

Seattle, Washington

This report is prepared as a preliminary description of the seismic activity in the state of Washington and western and central Oregon. Information contained in this report should be considered preliminary, and not cited for publication. Seismic network operation in Washington and western and central Oregon is supported by the following contracts:

U.S. Geological Survey
Joint Operating Agreement 1434-92-A-0963
and
Joint Operating Agreement 1434-92-A-0964

and

Westinghouse Hanford Company
Contract MLR-SVV-666685

CONTENTS

FIGURES

TABLES

INTRODUCTION

This is the second quarterly report of 1992 from the University of Washington Geophysics Program covering seismicity of all of Washington and western and central 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. Annual reports covering seismicity in Washington since 1969 are available from the U.W. Geophysics Program.

This quarterly report discusses network operations, seismicity of the region, and unusual events or findings. This report is 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. Fig. 1 is a map view of seismograph stations currently in operation.

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. Fig. 1 shows a map view of stations operating during the quarter.

In southern Oregon, station BBO replaced station WMO on the 9th of June. WMO was located at a site of significance to Native Americans, and the Forest Service requested that we re-site it.

OUTREACH ACTIVITIES

In addition to monitoring earthquake activity in Washington and much of Oregon, the staff of the Washington Regional Seismic Network participates in outreach projects to inform and educate the public about seismicity and natural hazards. This may take the form of lab tours, lectures, TV or radio talk shows, field trips, or participation in regional earthquake planning efforts. This quarter seismology lab tours included approximately 10 tours for elementary and middle school students and teachers, and 2 for high school and college age students. Several individual students came to us for mentoring or help with their projects, and presentations were made to multiple groups at several elementary schools. A field trip was arranged to Mount St. Helens for a foreign journalist at the request of the State Department, and two TV

special reports (for stations from Spokane and Seattle) featured Chris Trisler. Chris, who previously handled most of our public outreach, accepted a new position at FEMA on June 1. In Chris' absence, outreach will be handled mainly by Anthony Qamar and Ruth Ludwin, with additional participation from Steve Malone, Rick Benson, and our second year graduate students. Following the June 28 earthquakes in southern California, Rick Benson participated with Chris Trisler in an hour long TV talk show Tony Qamar handled press interviews in the lab, and Ruth Ludwin responded to questions from the public.

TABLE 1
Station Outages 2nd quarter 1992

Station	Outage Dates	Comments
FL2	May 4-June 16	Tx and VCO
PAT	May 5-May 12	Dead
ET3	May 5-May 12	Dead
OT2-May 19-End	Intermittent, hashed out	
VBE	June 16-June 20	Dead
GHW	April 17-April 23	Dead
WMO	June 9-End	REMOVED - Replaced by BBO
BBO	April 1 - June 9	NEW - Replaced WMO
STD	June 23-End	Dead
OSD	June 28-End	Dead
NLO	June 27-End	Dead batteries
YAK	April 8-April 17	Dead, interference with new antennae

Washington Regional Seismograph Network

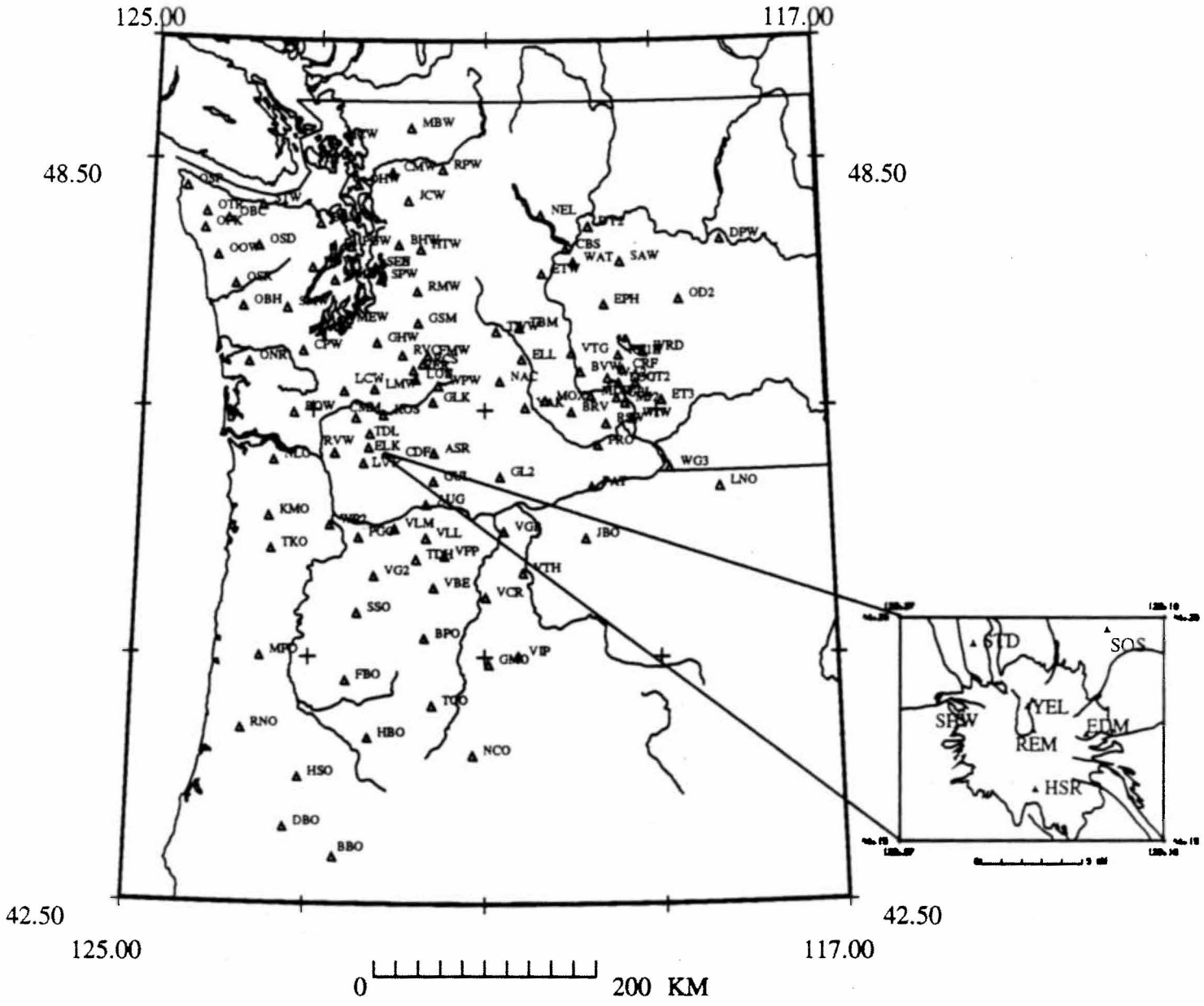

Figure 1: Stations operating at the end of the second quarter, 1992.

STATIONS USED FOR LOCATION OF EVENTS

Table 2 lists stations used in locating seismic events in Washington and Oregon. Stations marked by an asterisk (*) were supported by USGS joint operating agreement 1434-92-A-0964 Stations marked by (%) were supported by USGS joint operating agreement 1434-92-A-0963, and (+) indicates support under Westinghouse Hanford Company Contract MLR-SVV-666685 All other stations were supported from other sources.

The first column in the table gives the 3-letter station designator. This is followed by a symbol designating the funding agency, station north latitude and west longitude (in degrees, minutes and seconds), station elevation in km, and comments indicating landmarks for which stations were named.

TABLE 2

Stations Operating at the End of the Second Quarter 1992

STA	F	LAT	LONG	EL	NAME
ASR	%	46 09 02.4	121 35 33.6	1.280	Mt. Adams - Stagman Ridge
AUG	%	45 44 10.0	121 40 50.0	0.865	Augspurger Mtn
BBO	%	42 53 12.6	122 40 46.6	1.671	Butler Butte, Oregon
BHW	*	47 50 12.6	122 01 55.8	0.198	Bald Hill
BLN	*	48 00 26.5	122 58 18.6	0.585	Blyn Mt.
BOW	*	46 28 30.0	123 13 41.0	0.870	Boistfort Mt.
BPO	%	44 39 06.9	121 41 19.2	1.957	Bald Peter, Oregon
BRV	+	46 29 07.2	119 59 29.4	0.925	Black Rock Valley
BVW	+	46 48 30.6	119 52 48.0	0.707	Beverly
CBS	+	47 48 16.7	120 02 27.6	1.073	Chelan Butte, South
CDF	%	46 06 58.2	122 02 51.0	0.780	Cedar Flats
CMM	%	46 26 07.0	122 30 21.0	0.620	Crazy Man Mt.
CMW	*	48 25 25.3	122 07 08.4	1.190	Cultus Mtns.
CPW	*	46 58 25.8	123 08 10.8	0.792	Capitol Peak
CRF	+	46 49 30.6	119 23 18.0	0.260	Corfu
DBO	%	43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon
DPW	+	47 52 14.3	118 12 10.2	0.892	Davenport
DY2	+	47 59 06.9	119 46 13.0	0.884	Dyer Hill 2
EDM		46 11 50.4	122 09 00.0	1.609	East Dome, Mt. St. Helens
ELK	%	46 18 20.0	122 20 27.0	1.270	Elk Rock
ELL	+	46 54 34.8	120 33 58.8	0.789	Ellensburg
EPH	+	47 21 12.8	119 35 46.2	0.628	Ephrata
ET3	+	46 34 37.0	118 56 11.0	0.305	Eltopia (replaces ET2)

continued

STA	F	LAT	LONG	EL	NAME
ETW	+	47 36 16.2	120 19 51.6	1.475	Entiat
FBO	%	44 18 35.6	122 34 40.2	1.080	Farmers Butte, Oregon
FL2	%	46 11 47.0	122 21 01.0	1.378	Flat Top 2
FMW	*	46 56 29.6	121 40 11.3	1.859	Mt. Fremont
GBL	+	46 35 51.6	119 27 35.4	0.330	Gable Mountain
GHW	*	47 02 30.0	122 16 21.0	0.268	Garrison Hill
GL2	+	45 57 35.0	120 49 22.5	1.000	New Goldendale
GLK	%	46 33 50.2	121 36 30.7	1.320	Glacier Lake
GMO	%	44 26 20.8	120 57 22.3	1.689	Grizzlie Mountain, Oregon
GMW	*	47 32 52.5	122 47 10.8	0.506	Gold Mt.
GSM	*	47 12 11.4	121 47 40.2	1.305	Grass Mt.
GUL	%	45 55 27.0	121 35 44.0	1.189	Guler Mt.
HBO	%	43 50 39.5	122 19 11.9	1.615	Huckleberry Mt., Oregon
HDW	*	47 38 54.6	123 03 15.2	1.006	Hoodsport
HSO	%	43 31 33.0	123 05 24.0	1.020	Harness Mountain, Oregon
HSR	%	46 10 22.2	122 10 58.2	1.774	South Ridge, Mt. St. Helens
HTW	*	47 48 12.5	121 46 08.6	0.829	Haystack Lookout
JBO	+	45 27 41.7	119 50 13.3	0.645	Jordan Butte, Oregon
JCW	*	48 11 42.7	121 55 31.1	0.792	Jim Creek
JUN	%	46 08 48.0	122 09 10.8	1.049	June Lake
KMO	%	45 38 07.8	123 29 22.2	0.975	Kings Mt., Oregon
KOS	%	46 27 40.8	122 11 25.8	0.828	Kosmos
LCW		46 40 14.4	122 42 02.8	0.396	Lucas Creek
LMW	*	46 40 04.8	122 17 28.8	1.195	Ladd Mt.
LNO	+	45 52 15.8	118 17 06.0	0.768	Lincton Mt., Oregon
LO2	%	46 45 00.0	121 48 36.0	0.853	Longmire
LOC		46 43 04.8	119 25 54.6	0.201	Rohay Station
LVP	%	46 04 06.0	122 24 30.0	1.170	Lakeview Peak
MBW	*	48 47 02.4	121 53 58.8	1.676	Mt. Baker
MCW	*	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MDW	+	46 36 48.0	119 45 39.0	0.330	Midway
MEW	*	47 12 07.0	122 38 45.0	0.097	McNeil Island
MJ2		46 33 28.0	119 21 50.0	0.150	Rockwell Station
MOX	+	46 34 38.0	120 17 35.0	0.540	Moxie City
MPO	%	44 30 17.4	123 33 00.6	1.249	Mary's Peak, Oregon
MTM	%	46 01 31.8	122 12 42.0	1.121	Mt. Mitchell
NAC	+	46 43 59.4	120 49 25.2	0.728	Naches
NCO	%	43 42 14.4	121 08 18.0	1.908	Newberry Crater, Oregon
NEL	+	48 04 41.8	120 20 17.7	1.490	Nelson Butte
NLO	*	46 05 18.0	123 27 00.0	0.900	Nicolai Mt., Oregon
OBC	%	48 02 07.1	124 04 39.0	0.938	Olympics - Bonidu Creek
OBH	%	47 19 34.5	123 51 57.0	0.383	Olympics - Burnt Hill
OD2	+	47 23 27.6	118 42 38.4	0.590	Odessa site #2
OFK	%	47 57 00.0	124 21 28.1	0.134	Olympics - Forks
OHW	*	48 19 24.0	122 31 54.6	0.054	Oak Harbor

continued

STA	F	LAT	LONG	EL	NAME
ONR	%	46 52 37.5	123 46 16.5	0.257	Olympics - North River
OOW	%	47 44 12.0	124 11 22.0	0.743	Octopus West
OSD	*	47 49 15.0	123 42 06.0	2.010	Olympics - Snow Dome
OSP	%	48 17 05.5	124 35 23.3	0.585	Olympics - Sooes Peak
OSR		47 30 20.3	123 57 42.0	0.815	Olympics Salmon Ridge
OT2	+	46 43 17.0	119 14 05.0	0.355	New Othello (replaces OTH 12/1
OTR	%	48 05 00.0	124 20 39.0	0.712	Olympics - Tyee Ridge
PAT	+	45 52 50.1	119 45 40.1	0.300	Paterson
PGO	%	45 28 00.0	122 27 10.0	0.237	Gresham, Oregon
PGW	*	47 49 18.8	122 35 57.7	0.122	Port Gamble
PRO	+	46 12 45.6	119 41 09.0	0.552	Prosser
RC1E		46 56 36.0	119 26 00.0	0.500	Royal City,E-W comp
RC1N		46 56 36.0	119 26 00.0	0.500	Royal City,N-S comp
RC1Z		46 56 36.0	119 26 00.0	0.500	Royal City
RCS		46 52 15.6	121 43 52.0	2.877	Mt. Rainier, Camp Schurman
REM		46 11 57.0	122 11 03.0	2.102	Rembrandt (Dome station)
RER		46 49 09.2	121 50 27.3	1.756	Mt. Rainier, Emerald Ridge
RMW	*	47 27 35.0	121 48 19.2	1.024	Rattlesnake Mt. (West)
RNO	%	43 54 44.0	123 44 26.0	0.875	Roman Nose, Oregon
RPW	*	48 26 54.0	121 30 49.0	0.850	Rockport
RSW	+	46 23 28.2	119 35 19.2	1.037	Rattlesnake Mt. (East)
RVC	%	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek
RVW	*	46 08 58.2	122 44 37.2	0.460	Rose Valley
SAW	+	47 42 06.0	119 24 03.6	0.690	St. Andrews
SEA		47 39 18.0	122 18 30.0	0.030	Seattle Wood-Andersons
SEE		47 39 18.0	122 18 30.0	0.030	Seattle Pseudo-WA (E)
SEN		47 39 18.0	122 18 30.0	0.030	Seattle Pseudo-WA (N)
SHW	*	46 11 50.6	122 14 08.4	1.399	Mt. St. Helens
SMW	*	47 19 10.2	123 20 30.0	0.840	South Mt.
SOS	%	46 14 38.5	122 08 12.0	1.270	Source of Smith Creek
SPW	*	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle
SSO	%	44 51 21.6	122 27 37.8	1.242	Sweet Springs, Oregon
STD	%	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
STW	*	48 09 02.9	123 40 13.1	0.308	Striped Peak
TBM	+	47 10 10.1	120 35 54.0	1.064	Table Mt.
TCO	%	44 06 21.0	121 36 01.0	1.975	Three Creek Meadows, Oregon.
TDH	%	45 17 23.4	121 47 25.2	1.541	Tom,Dick,Harry Mt., Oregon
TDL	%	46 21 03.0	122 12 57.0	1.400	Tradedollar Lake
TKO	%	45 22 16.7	123 27 14.0	1.024	Trask Mtn, Oregon
TWW	+	47 08 17.2	120 52 04.5	1.046	Teanaway
VBE	%	45 03 37.2	121 35 12.6	1.544	Beaver Butte, Oregon
VCR	%	44 58 58.2	120 59 17.4	1.015	Criterion Ridge, Oregon
VFP	%	45 19 05.0	121 27 54.3	1.716	Flag Point, Oregon
VG2	%	45 09 20.0	122 16 15.0	0.823	Goat Mt., Oregon
VGB	+	45 30 56.4	120 46 39.0	0.729	Gordon Butte, Oregon
VIP	%	44 30 29.4	120 37 07.8	1.731	Ingram Pt., Oregon

continued

STA	F	LAT	LONG	EL	NAME
VLL	%	45 27 48.0	121 40 45.0	1.195	Laurance Lk., Oregon
VLM	%	45 32 18.6	122 02 21.0	1.150	Little Larch, Oregon
VTG	+	46 57 28.8	119 59 14.4	0.208	Vantage
VTH	%	45 10 52.2	120 33 40.8	0.773	The Trough, Oregon
WA2	+	46 45 24.2	119 33 45.5	0.230	Wahluke Slope
WAT	+	47 41 55.0	119 57 15.0	0.900	Waterville
WG3	+	46 01 43.0	118 51 24.0	0.480	Wallula Gap
WIW	+	46 25 48.8	119 17 13.4	0.130	Wooded Island
WP2	%	45 33 57.2	122 47 06.9	0.341	West Portland, Oregon(replaces
WPW	%	46 41 53.4	121 32 48.0	1.250	White Pass
WRD	+	46 58 11.4	119 08 36.0	0.378	Warden
YAK	+	46 31 43.8	120 31 14.4	0.629	Yakima
YEL		46 12 35.0	122 11 16.0	1.750	Yellow Rock, Mt. St. Helens

EARTHQUAKE DATA

There were 1048 events processed by the University of Washington digital recording seismic network between April 1 and June 30, 1992. Locations were determined for 744 of these in Washington and Oregon; 601 of these were classified as earthquakes and 143 as known or suspected blasts. The remaining 304 processed events include teleseisms (155 events), regional events outside the U. W. network (128), and unlocated events within the U. W. network. Unlocated events within the U.W. network include very small earthquakes and some known blasts. For example, only a few of the frequent mine blasts at Centralia are routinely processed.

Table 3 is the catalog of earthquakes and blasts located within the network for this quarter. Fig. 2 shows all earthquakes with magnitude greater than or equal to 0.0 ($M_c \geq 0.$) Fig. 3 shows blasts and probable blasts ($M_c \geq 0.$) Fig. 4 shows earthquakes located at Mt. Rainier ($M_c \geq 0$). Fig. 5 shows earthquakes located at Mt. St. Helens ($M_c \geq 0$).

Western Washington and Oregon

During the first quarter of 1992, 526 earthquakes were located between 42.5° and 49.5° north latitude and between 121° and 125° west longitude. Most of these occurred at depths less than 30 km with, as usual, a small number of earthquakes in the Puget Sound lowland and near the Olympic Peninsula at depths greater than 30 km.

There were three earthquakes reported felt in western Washington and Oregon this quarter. The first felt earthquake had M_c = 2.7, and was located at less than 5 km depth. It occurred on April 18 approximately 10 km NE of Deming, Washington and several Deming residents reported it to the local radio and TV stations. On June 6, an earthquake of similar size and depth, located about 20 km ENE of Eugene was reported felt in western Oregon in the Springfield-Mohawk Valley-Marcola Area. A very small earthquake, M_c =1.6, at ~25 km depth and located 17 km west of Seattle, was reported felt by a very sensitive citizen of that city on June 20. However, no one reported feeling a magnitude 3.1 earthquake on April 19, at ~ 23 km depth, located 27 km SSE of Seattle near Maple Valley.

Eastern Washington and Oregon

During this quarter, 75 earthquakes were located in Eastern Washington, none larger than magnitude 2.4, and none were reported felt.

Mount Rainier Area

There were 160 events in the region near Mt. Rainier, as seen in Fig. 5. Of these, 43 were located in what is called the 'western zone', a north-south trending lineation of seismicity approximately 15 km west of the summit of Mt. Rainier. The rest were a combination of tectonic (28) and surficial events (70), with epicenters within 5 km of the summit. The remaining events were scattered around the cone of Rainier as seen in Fig. 5.

Activity at Mt. Rainier includes surface events (avalanches, ice quakes, etc.) and tectonic earthquakes. Earthquakes in our catalog flagged with type "L" (for low frequency), are generally surficial events. Shallow tectonic earthquakes have a higher frequency and a different source. The number of events in close proximity to the cone of Mt. Rainier varies over the course of the year, since the source of much of the shallow surface-type activity is presumably ice movement or avalanching, which is seasonal in nature.

Mount St. Helens Area

In the second quarter, 123 events (tectonic or surficial) were located at Mt. St. Helens, with 49 earth-

quakes deeper than 4 km. The two largest events each had a magnitude of M_c = 2.1 and occurred on April 14 and May 2.

Other Sources for Earthquake Information

In addition to this publication, information on recent earthquakes is available from several sources. Via computer, a non-interactive account on the University of Washington Geophysics Program computer with login name "quake" and password, "quake" provides the latest information about earthquakes world-wide (from the National Earthquake Information Center) and from the Pacific Northwest (from the Washington Regional Seismograph Network). To receive this information by modem, dial (206) 685-0889 at either 1200 or 2400 baud or use "finger quake@geophys.washington.edu" on InterNet. We also provide automatic computer-generated alert messages by E-Mail or FAX to institutions needing such information, and we regularly exchange phase data via E-mail with other regional seismograph network operators. To request information by E-mail, contact rick@geophys.washington.edu.

Earthquake information in the quarterlies is published in final form by the Washington State Department of Natural Resources as information circulars entitled "Earthquake Hypocenters in Washington and Northern Oregon" covering the period 1970-1986 (see circulars #53,56,64-66,72,79,82-84). A catalog covering earthquakes in 1987-1989 is in preparation. These circulars, plus circular #85, "Washington State Earthquake Hazards", are available from Washington Dept. of Natural Resources, Division of Geology and Earth Resources, Post Office Box 47007, Olympia, Wa. 98504-7007, or by telephone at (206) 459-6372.

Other regional agencies provide earthquake information. These include the Geological Survey of Canada (Pacific Geoscience Centre, Sidney, B.C. FAX (604) 363-6565), which produces monthly summaries of Canadian earthquakes; the United States Geological Survey which produces weekly reports called "Seismicity Reports for Northern California" (USGS, attn: Steve Walter, 345 Middlefield Rd, MS-977,rMenlo Park, Ca, 94025) and "Weekly Earthquake Report for Southern California" (USGS, attn: Dr. Kate Hutton or Dr. Lucy Jones, California Institute of Technology, Pasadena, Ca.)

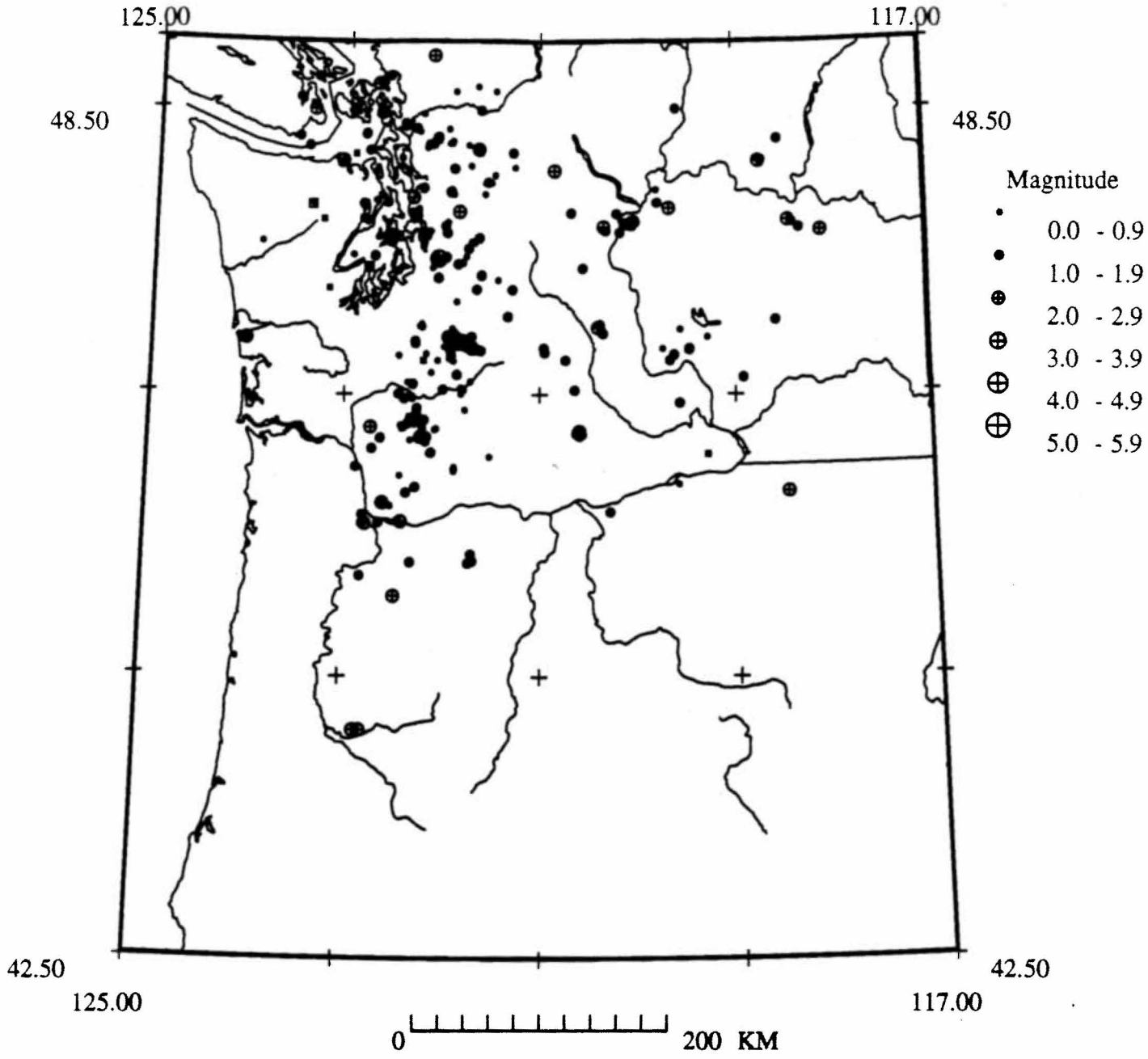

Figure 2: Earthquakes located in Washington and Oregon with magnitudes greater or equal to 0. during the second quarter of 1992. Square symbols indicate events located at depths of 30 km or more.

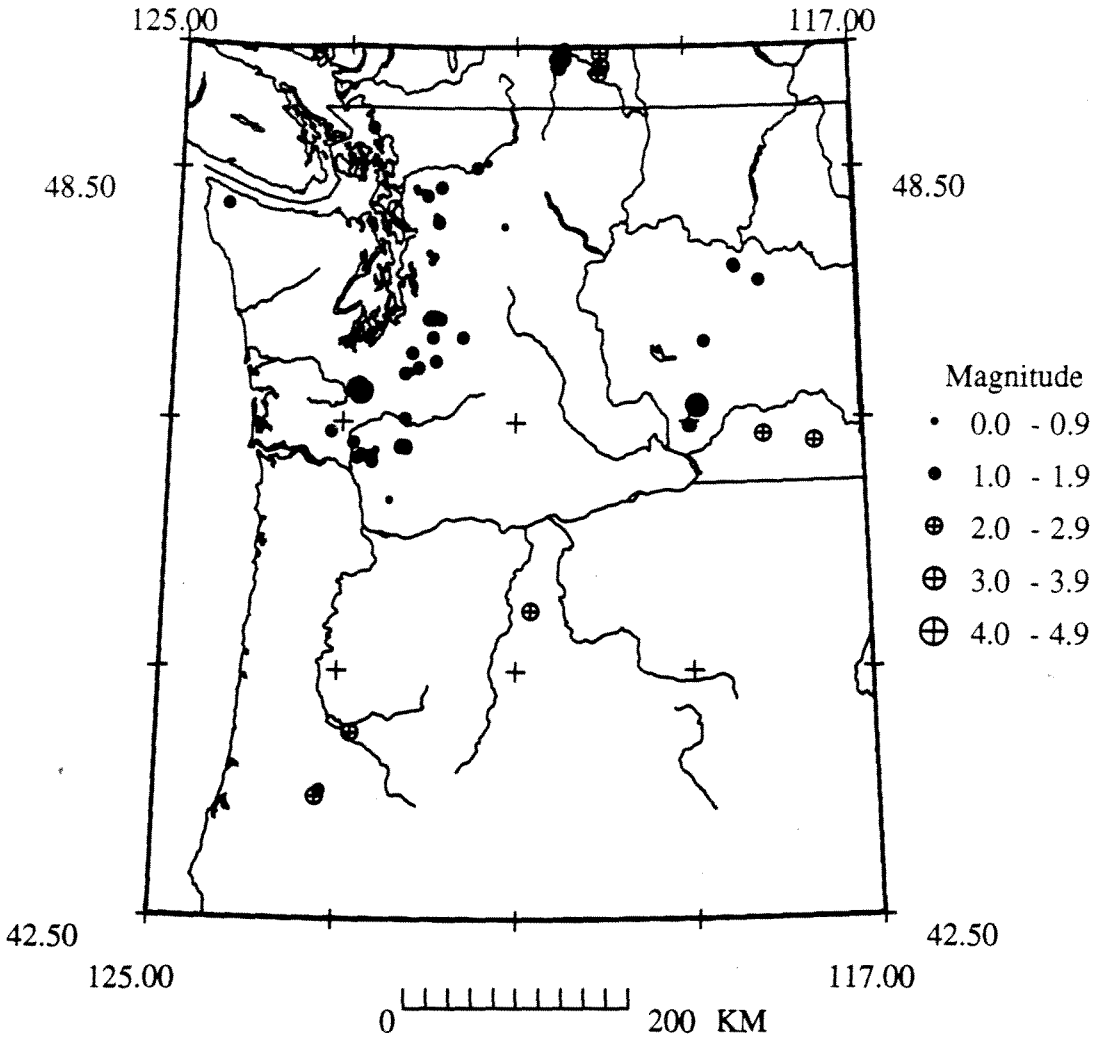

Figure 3: Blasts and probable blasts during the second quarter of 1992.

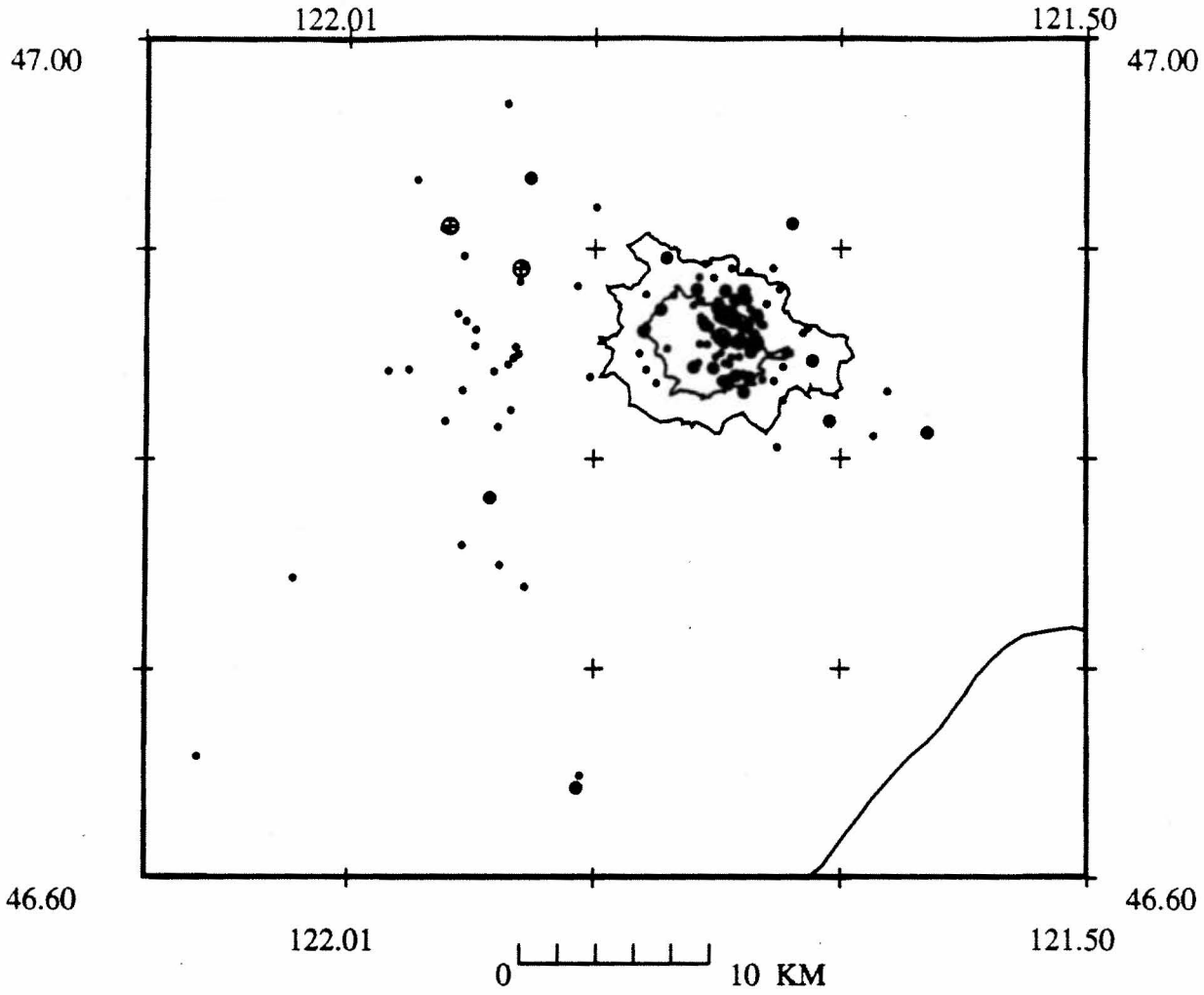

Figure 4: Earthquakes located in the Mt. Rainier area second quarter, 1992. All events are greater than 0.0. Inner contour is the 10,000 foot elevation contour, and the outer is the 7,500 foot contour.

TABLE 2

Earthquakes Second Quarter 1992

Apr 1992

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
1	05:25:29.42	48 22.43	122 17.90	16.87	1.5	11/13	82	0.16	BA	P3	
1	08:06:25.63	46 12.36	122 11.53	2.00	0.3	11/14	85	0.10	AA	S3	
1	14:04:28.24	48 24.57	122 25.24	19.71	1.4	13/18	92	0.29	BB	P3	
1	14:08:21.74	46 35.64	121 42.70	2.62$	0.8	13/19	65	0.22	CB	P3	
1	15:49:57.37	46 51.51	121 44.88	0.05*	0.9	5/05	158	0.39	CD	C3	L
1	17:41:08.34	46 16.84	122 25.13	18.15	0.7	19/32	98	0.11	AB	S3	
1	17:47:50.17	46 16.68	122 24.62	17.01	0.1	11/14	96	0.10	AB	S3	
1	19:24:58.10	48 12.25	121 17.26	2.88$	1.0	10/13	133	0.40	DC	P3	
1	21:58:53.67	47 19.61	121 55.40	3.16	1.3	7/07	206	0.15	BD	P3	P
1	23:09:57.21	46 45.88	122 50.75	11.95	2.1	24/25	94	0.27	BB	P3	P
2	00:01:51.98	49 23.76	120 30.20	0.04*	1.7	12/12	276	0.56	DD	C3	R
2	01:48:20.16	46 18.09	122 20.91	0.03*	0.2	9/10	130	0.26	BB	S3	P
2	01:53:47.40	45 12.62	122 48.34	27.05	1.6	29/32	119	0.30	BB	O0	
2	06:07:30.59	47 42.67	120 01.02	6.45	0.4	7/11	101	0.19	BB	N3	
2	06:30:35.65	46 11.92	122 11.46	6.08	-0.4	7/08	100	0.06	AB	S3	
2	13:07:04.98	46 51.68	121 55.29	11.55	0.3	7/11	191	0.14	BD	C3	
2	13:19:24.14	46 51.30	121 43.68	0.02#	0.0	5/05	183	0.54	DD	C3	L
2	15:30:22.15	46 53.43	121 43.00	0.02#	0.0	4/04	172	0.19	BD	C3	L
2	17:18:56.61	46 45.52	121 55.85	0.04*	0.5	10/15	101	0.18	BB	C3	
2	19:17:57.23	48 21.37	122 12.07	3.84	0.9	5/05	130	0.43	CD	P3	P
2	20:00:10.83	49 22.35	120 28.48	0.04*	0.0	12/12	270	0.48	CD	C3	R
2	22:10:43.77	48 21.94	121 54.09	0.05*	1.0	8/10	101	0.50	CC	P3	P
3	00:55:22.41	46 51.81	121 43.46	0.04*	0.0	5/05	181	0.30	BD	C3	L
3	02:33:18.84	46 12.16	122 11.45	1.59	0.5	11/17	90	0.06	AA	S3	
3	15:52:15.10	47 46.76	120 41.06	0.82	1.1	12/14	77	0.34	CC	N3	
3	17:48:42.04	46 54.55	121 56.66	13.72	0.2	8/15	106	0.14	AB	C3	
3	20:48:24.16	46 51.81	121 43.38	0.03#	0.8	4/04	182	0.25	BD	C3	L
4	02:48:06.14	46 17.95	122 19.06	1.23	0.8	12/13	96	0.31	CB	S3	P
4	10:20:30.75	46 51.05	121 43.90	0.03*	1.2	5/05	182	0.08	AD	C3	L
4	19:21:34.55	47 42.00	120 03.35	4.14	1.8	13/18	90	0.10	AB	N3	
4	19:32:28.95	47 51.15	119 47.63	0.51	1.1	4/08	112	0.43	CD	N3	
4	20:07:40.39	46 50.99	121 53.52	11.59	0.1	5/09	179	0.11	AD	C3	
4	23:36:58.91	48 30.04	121 37.57	0.02*	1.6	11/15	155	0.28	BC	P3	
5	03:03:44.75	46 12.41	122 11.69	5.53	0.2	13/21	85	0.07	AA	S3	
5	05:08:55.46	47 42.85	120 01.44	6.02	1.2	10/17	87	0.31	CA	N3	
5	08:19:10.08	46 50.69	121 53.96	11.16	0.5	6/11	125	0.10	AC	C3	
5	08:25:29.16	46 50.88	121 53.73	11.65	0.4	6/11	123	0.11	AC	C3	
5	12:48:47.06	48 04.71	120 51.40	7.18#	2.0	21/26	134	0.53	DC	C3	
5	15:03:39.05	46 33.01	121 48.69	5.63	0.7	10/15	93	0.10	AC	C3	
5	17:46:49.22	46 28.30	122 23.04	16.20	1.7	33/45	42	0.13	AA	S3	
5	19:06:04.26	49 25.47	120 28.89	0.04*	0.0	13/14	273	0.70	DD	C3	R
5	22:30:42.93	48 16.50	122 06.47	13.85	0.2	5/07	202	0.17	BD	P3	
6	02:42:10.17	46 48.76	121 54.50	11.56	-0.1	5/10	208	0.14	AD	C3	
6	03:51:52.34	46 30.39	122 26.58	19.73	1.7	37/59	46	0.11	AA	C3	
6	07:05:02.73	48 13.88	121 39.08	4.41$	1.9	19/22	76	0.33	CC	P3	
6	09:18:32.36	48 09.92	122 26.71	8.75	0.4	9/11	89	0.27	BC	P3	
6	13:39:20.59	46 28.11	122 23.66	17.19	0.4	22/29	65	0.13	AA	S3	
6	20:18:47.77	43 32.47	123 10.12	2.36	1.9	5/06	165	0.15	BD	O0	P
6	22:38:54.35	46 19.77	122 14.13	10.34	0.0	8/11	128	0.05	AB	S3	
7	05:56:23.08	46 48.72	121 58.01	8.81	-0.1	6/10	238	0.10	AD	C3	
7	15:35:13.28	46 50.79	121 41.35	3.34	1.6	5/05	212	0.27	CD	C3	L
7	18:45:02.27	48 19.94	122 11.20	0.05#	0.9	4/04	254	0.39	CD	P3	P
7	20:15:29.75	47 37.65	122 11.86	24.56	2.0	29/32	54	0.11	AA	P3	
7	22:40:22.01	46 12.05	122 11.01	6.08	0.0	11/15	94	0.07	AB	S3	
7	22:40:39.50	46 12.11	122 11.04	6.17	0.6	16/21	55	0.07	AA	S3	
7	23:49:48.84	46 18.55	122 19.81	0.67	1.7	28/31	48	0.14	AA	S3	P
8	00:23:55.74	46 12.09	122 10.99	5.72	0.2	10/15	94	0.06	AB	S3	
8	01:05:30.57	48 50.25	122 43.50	5.00*	1.2	5/05	251	0.49	CD	P3	P
8	02:33:12.89	46 51.33	121 43.79	0.03*	1.2	5/05	181	0.17	BD	C3	L
8	08:48:21.85	47 25.31	121 51.08	12.41	1.6	20/25	76	0.16	BA	P3	

Apr 1992 cont'd

DAY	TIME	LAT	LON	DEPTH	M	NS/NP	GAP	RMS	Q	MOD	TYP
8	10:44:55.15	46 12.35	122 11.60	3.86	-0.5	6/09	90	0.11	AC	S3	
8	10:59:52.63	46 12.12	122 11.57	1.81	0.3	13/16	76	0.08	AA	S3	
8	21:06:16.03	49 18.31	120 04.28	17.03	2.1	11/11	252	0.60	DD	C3	R
8	21:10:14.29	46 53.43	121 44.73	4.97	0.5	5/05	116	0.04	AD	C3	L
8	21:44:22.16	46 46.95	122 49.89	6.62*	2.6	21/21	90	0.13	AC	P3	P
9	01:18:21.86	46 17.71	122 20.35	1.19	0.1	6/07	136	0.19	BC	S3	P
9	17:58:52.79	46 52.50	121 46.09	4.50	0.1	5/08	109	0.12	AD	C3	
9	18:59:58.41	49 28.08	120 28.35	0.03*	0.0	11/11	262	0.66	DD	C3	R
9	19:32:31.36	46 51.22	121 55.33	10.82	0.1	7/11	195	0.10	AD	C3	
9	21:26:31.18	47 50.46	122 50.57	15.36*	1.0	9/11	83	0.21	BB	P3	
9	22:08:09.55	47 42.36	120 07.02	0.56	1.8	16/19	80	0.58	DC	N3	
9	23:46:16.41	47 52.10	122 42.61	0.58	0.8	7/08	87	0.17	BB	P3	
10	05:36:55.54	46 50.32	121 44.78	0.81	0.8	5/05	179	0.18	BD	C3	L
10	09:58:53.08	46 51.64	121 41.61	0.04*	-0.3	4/06	204	0.11	AD	C3	L
10	12:29:12.22	46 53.05	121 53.48	7.82	0.3	6/11	159	0.26	BC	C3	
10	15:39:13.48	46 14.12	122 06.25	10.06	-0.2	11/18	118	0.08	AB	S3	
10	21:21:36.10	45 52.28	122 27.06	6.06	0.9	20/22	175	0.29	BC	C3	P
10	22:09:34.33	49 21.57	119 57.88	0.04*	0.0	11/11	281	0.34	CD	C3	R
11	11:18:38.45	46 52.00	121 43.87	0.04*	0.2	4/04	175	0.05	AD	C3	L
11	23:11:11.90	48 19.34	122 06.59	0.02*	0.8	5/06	133	0.32	CD	P3	P
12	01:22:38.03	46 32.05	121 46.75	1.33	0.6	13/18	117	0.14	AC	C3	
12	09:03:29.33	47 46.92	122 17.06	24.65*	1.6	26/26	41	0.13	AA	P3	
12	13:42:44.03	46 29.93	122 19.87	19.21	0.9	23/33	68	0.15	AA	S3	
12	21:01:07.16	45 35.32	122 37.56	14.67	1.1	12/13	114	0.37	CB	C3	
12	22:31:02.78	46 12.05	122 11.42	2.27	0.4	8/10	99	0.07	AB	S3	
13	01:48:52.62	46 54.46	121 57.31	14.85	-0.3	6/09	194	0.08	AD	C3	
13	07:14:10.28	46 14.54	122 06.67	9.60	-0.2	12/18	118	0.07	AB	S3	
13	07:58:57.38	46 51.29	121 44.39	0.02*	1.2	8/08	85	0.16	BA	C3	L
13	12:12:54.52	46 12.26	122 11.31	1.56	0.5	12/15	89	0.06	AA	S3	
13	14:48:16.20	46 44.60	122 02.85	9.57	0.2	10/14	128	0.09	AB	C3	
13	15:04:12.95	46 52.13	121 46.33	0.03*	-0.2	4/04	180	0.03	AD	C3	L
13	21:04:10.24	46 12.87	122 49.32	4.30	1.6	22/22	58	0.19	BB	C3	P
13	22:46:07.91	48 05.66	121 55.79	0.05*	1.1	8/10	121	0.23	BC	P3	P
13	23:02:33.36	49 25.83	120 27.78	0.03*	1.9	14/14	251	0.62	DD	C3	R
13	23:57:23.73	46 37.39	118 53.80	1.25	2.2	22/22	201	0.18	BD	E3	P
14	06:12:04.49	46 49.95	121 55.84	7.64	0.6	11/17	140	0.12	AC	C3	
14	09:12:19.50	46 49.61	119 44.43	5.21	0.5	6/09	142	0.29	BC	E3	
14	10:46:30.30	46 51.56	121 54.42	11.73	-0.1	6/11	183	0.13	AD	C3	
14	17:26:45.79	46 44.66	120 44.34	1.04	1.4	13/14	85	0.18	BB	C3	
14	19:35:32.76	46 51.76	121 44.23	0.02*	1.1	5/07	173	0.06	AD	C3	L
14	20:04:11.29	47 08.14	118 48.91	0.04*	1.6	19/20	189	0.34	CD	N3	P
14	21:32:08.15	49 24.33	119 53.32	0.04*	0.0	9/09	287	0.29	CD	C3	R
14	23:01:54.25	49 18.37	120 31.91	0.02*	0.0	13/13	267	0.51	DD	C3	R
14	23:59:32.09	46 12.07	122 11.31	1.13	2.1	21/22	55	0.11	AA	S3	
15	07:13:00.45	47 43.73	123 15.22	41.35	0.6	6/09	107	0.17	BC	P3	
15	12:38:30.07	47 37.69	122 11.65	25.10*	1.3	19/22	91	0.19	BB	P3	
15	16:31:32.04	48 19.06	122 05.75	0.02*	0.9	7/07	104	0.26	BC	P3	
15	19:00:53.90	49 12.53	120 31.83	0.04*	0.0	15/15	255	0.72	DD	P1	R
15	20:17:55.41	48 08.55	118 44.18	0.34#	2.0	8/10	229	0.42	CD	N3	
16	00:36:04.01	46 18.52	122 16.53	1.36	1.0	22/26	61	0.14	AB	S3	P
16	08:52:49.48	46 12.08	122 12.17	1.92	0.1	7/08	253	0.12	BD	S3	
16	13:23:21.27	48 17.84	118 32.06	26.95*	1.3	4/04	263	0.00	AD	N3	
16	17:02:41.63	43 29.47	123 12.62	0.04*	2.1	4/05	133	0.34	CD	O0	P
16	19:32:35.26	49 09.94	120 05.08	0.03*	1.9	10/10	281	0.44	CD	N3	R
16	20:39:39.86	46 25.14	123 07.96	0.02*	1.1	5/05	96	0.07	AD	P3	P
17	03:22:56.67	48 30.81	119 35.71	6.89	1.9	11/13	217	0.48	CD	N3	
17	05:04:07.95	48 23.87	122 23.30	19.97*	1.3	9/10	86	0.19	BA	P3	
17	13:35:23.29	46 50.42	121 44.21	0.02#	0.9	4/04	184	0.19	BD	C3	L
18	01:59:29.20	46 55.94	121 57.74	14.25	0.4	6/08	179	0.06	AC	C3	
18	06:58:52.88	48 08.92	118 42.57	8.09	1.6	5/05	232	0.05	AD	N3	
18	08:16:25.54	46 52.83	121 46.16	0.02*	1.1	5/05	113	0.43	CD	C3	L
18	18:58:41.63	46 58.09	121 54.01	11.48	0.1	6/11	134	0.07	AC	C3	
18	20:47:06.62	48 53.27	122 07.50	2.85$	2.7	15/20	238	0.46	CD	P3	F
19	05:48:07.29	47 28.22	121 58.32	20.46	1.3	21/25	82	0.17	BA	P3	
19	08:06:58.01	45 43.92	122 35.49	19.17	2.2	49/53	39	0.24	BB	C3	

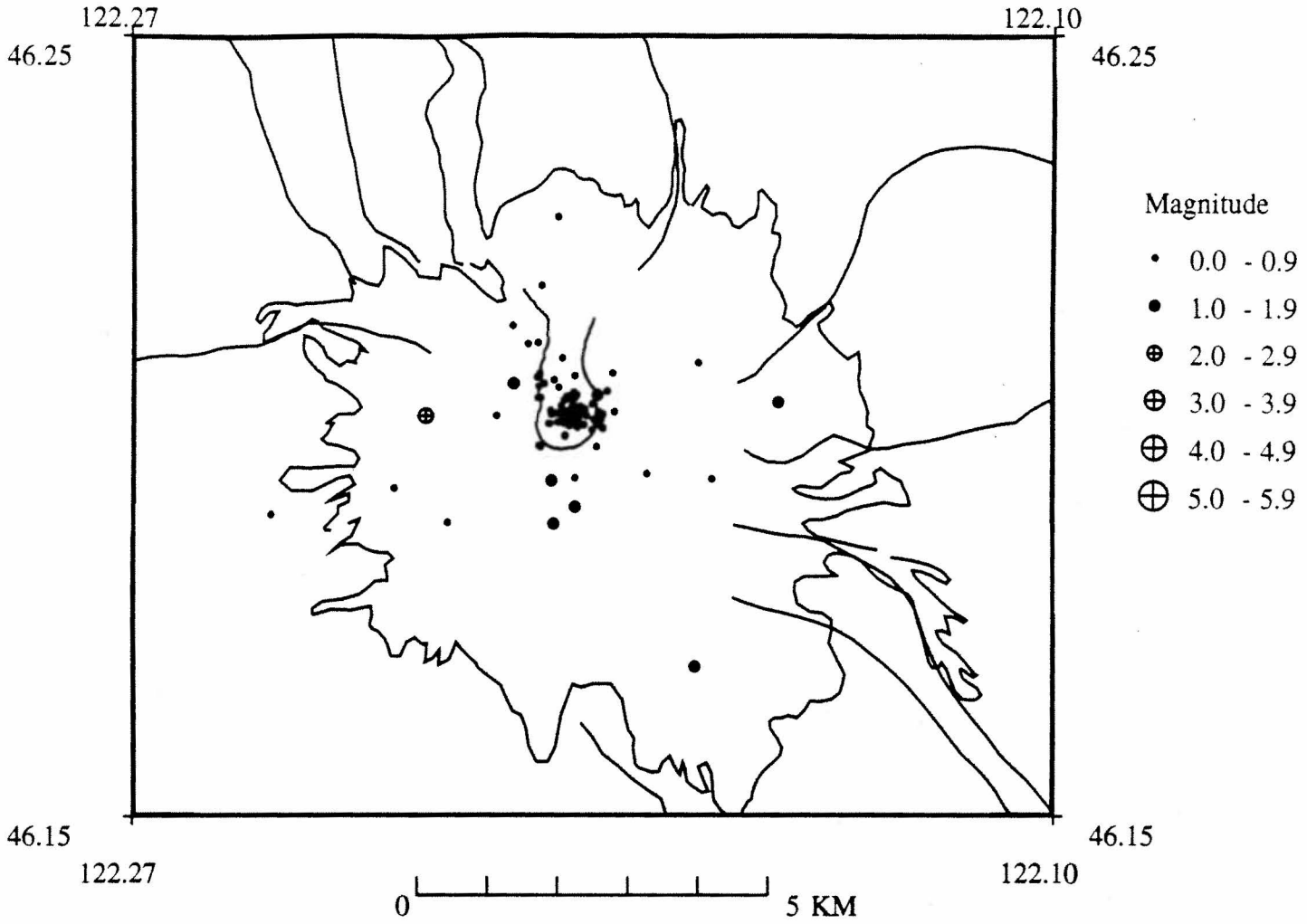

Figure 5: Earthquakes located in the Mt. St. Helens area during the second quarter, 1992. All events were shallower than 30 km.

Key to Earthquake Catalog in Table 3

TIME Origin time is calculated for each earthquake on the basis of multistation arrival times. Time is given in **Coordinated Universal Time** (UTC), in hours:minutes:seconds. To convert to Pacific Standard Time (PST) subtract eight hours, or to Pacific daylight time subtract seven hours.

LAT North latitude of the epicenter, in degrees and minutes.

LONG West longitude of the epicenter, in degrees and minutes.

DEPTH The depth, given in kilometers, is usually freely calculated 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.

MAG Coda-length magnitude M_c. An estimate of local Richter magnitude (Richter, C.F., 1958, Elementary Seismology: W.H. Freeman and Co., 768p), calculated using the coda-length/magnitude relationship determined for Washington (Crosson, R.S., 1972, Bull. Seism. Soc. Am., v. 62, p. 1133-1171). Where blank, data were insufficient for a reliable magnitude determination. Normally, the only earthquakes with undetermined magnitudes are very small ones. Magnitudes may be revised as we improve our analysis procedure.

NS/NP **NS** is the number of station observations, and **NP** the number of P and S phases used to calculate the earthquake location. A minimum of three stations and four phases are required. Generally, more observations improve the quality of the solution.

GAP Azimuthal gap. The largest angle (relative to the epicenter) containing no stations.

RMS The root-mean-square residual (observed arrival time minus predicted arrival time) at all stations used to locate the earthquake. It is only useful as a measure of the quality 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.

Q Two **Quality factors** indicate 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 is a measure of the hypocenter quality based on travel time residuals. For example: **A** quality requires an **RMS** less than 0.15 sec while 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, 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, **NP** , is 5 or less or **GAP** > 180° or **DMIN** > 50 km the solution is assigned quality **D**.

MOD The crustal velocity model used in location calculations.

- **P3** - Puget Sound model
- **C3** - Cascade model
- **S3** - Mt. St. Helens model including Elk Lake
- **N3** - northeastern model
- **E3** - southeastern model
- **O0** - Oregon model

TYP Events flagged in Table 3 use the following code:

- **F** - earthquakes reported to have been felt
- **P** - probable explosion
- **L** - low frequency earthquakes
- **H** - handpicked from helicorder records
- **X** - known explosion

QUARTERLY NETWORK REPORT 92-C

on

Seismicity of Washington and Northern Oregon

July 1 through September 30, 1992

Geophysics Program

University of Washington

Seattle, Washington

This report is prepared as a preliminary description of the seismic activity in the state of Washington and western and central Oregon. Information contained in this report should be considered preliminary, and not cited for publication. Seismic network operation in Washington and western and central Oregon is supported by the following contracts:

U.S. Geological Survey
Joint Operating Agreement 1434-92-A-0963
and
Joint Operating Agreement 1434-92-A-0964

and

Westinghouse Hanford Company
Contract MLR-SVV-666685

CONTENTS

FIGURES

TABLES

INTRODUCTION

This is the third quarterly report of 1992 from the University of Washington Geophysics Program covering seismicity of all of Washington and western and central 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. Annual technical reports covering seismicity in Washington since 1969 are available from the U.W. Geophysics Program.

This quarterly report discusses network operations, seismicity of the region, and unusual events or findings. This report is 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. Fig. 1 is a map view of seismograph stations currently in operation.

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. Fig. 1 shows a map view of stations operating during the quarter.

This quarter a new type of seismograph was installed at Longmire in Mt. Rainier National Park. It includes a broadband 3-component Guralp seismometer having a frequency response to ground velocity that is flat between 0.01 and 25 Hz and a Reftek digital recorder that samples the signals at the site at 50 samples per second. This station is at the same location as an existing DWWSSN station, LON, as well as one of our short-period telemetry stations, LO2. The equipment is being field-tested and the recorded data are being compared to data recorded by other instruments. Data from this instrument is not continuously telemetered to the University of Washington, but is remotely dialed-up by telephone and information downloaded via modem for time segments pertaining to events of interest. We began recovering and analyzing data from this station on June 28. During this quarter, ten earthquakes of all types (regional, local, and teleseismic) have been downloaded and incorporated into our database. The number of earthquakes downloaded should increase significantly after the initial test period ends in the fall of 1992.

Station WMO was moved to a new site near Crater Lake (BBO) at the request of the US Forest Service because the old site was too close to a native American cultural site.

TABLE 1
Station Outages 3rd quarter 1992

Station	Outage Dates	Comments
BHW	August 6-Sept 6	Dead, power supply
CMM	August 4-August 6	Dead
HTW	August 4-August 6	Dead
MDW	Sept 2-Sept 8	Dead
NCO	August 28-Sept 19	Dead
NLO	June 27-End	Dead batteries
OBC	Beginning to July 17	Dead
OSD	July 1-Sept 23	Dead
OTR	July 1-July 16	Dead
REM	July 30-Sept 29	Dead
RMW	August 4-August 10	Dead
SMW	August 31-End	Dead;VCO
VFP	August 22-End	Dead
VIP	August 28-End	Dead
WG2	July 1-July 17	Moved from WG3
WG3	July 17-End	REMOVED - Reoccupied WG2 site
WMO	June 9-End	REMOVED - Replaced by BBO

OUTREACH ACTIVITIES

In addition to monitoring earthquake activity in Washington and much of Oregon, the staff of the Washington Regional Seismic Network participates in outreach projects to inform and educate the public about seismicity and natural hazards. This may take the form of lab tours, lectures, TV or radio talk shows, field trips, or participation in regional earthquake planning efforts.

During the third quarter, we conducted 9 tours of the Seismology lab. In addition, a half-dozen or so individuals (including several emergency personnel with educational responsibilities) toured the lab and four interviews were videotaped for local TV stations following the eruption of Mt. Spurr in Alaska. Ruth Ludwin attended several executive board meetings of the Puget Sound Earthquake Project, a preparedness effort. Following the Landers and Big Bear earthquakes in California at the end of June, and continuing through most of July, we received lots of phone calls. Phone calls were also especially frequent during the last week in September, when a rumor of an earthquake prediction made the rounds.

Steve Malone attended a meeting of the Caltech Earthquake Research Associates group to participate in and learn about the southern California CUBE (Caltech-USGS Broadcast of Earthquakes) project with an aim to developing similar outreach and cooperative projects in the Pacific Northwest.

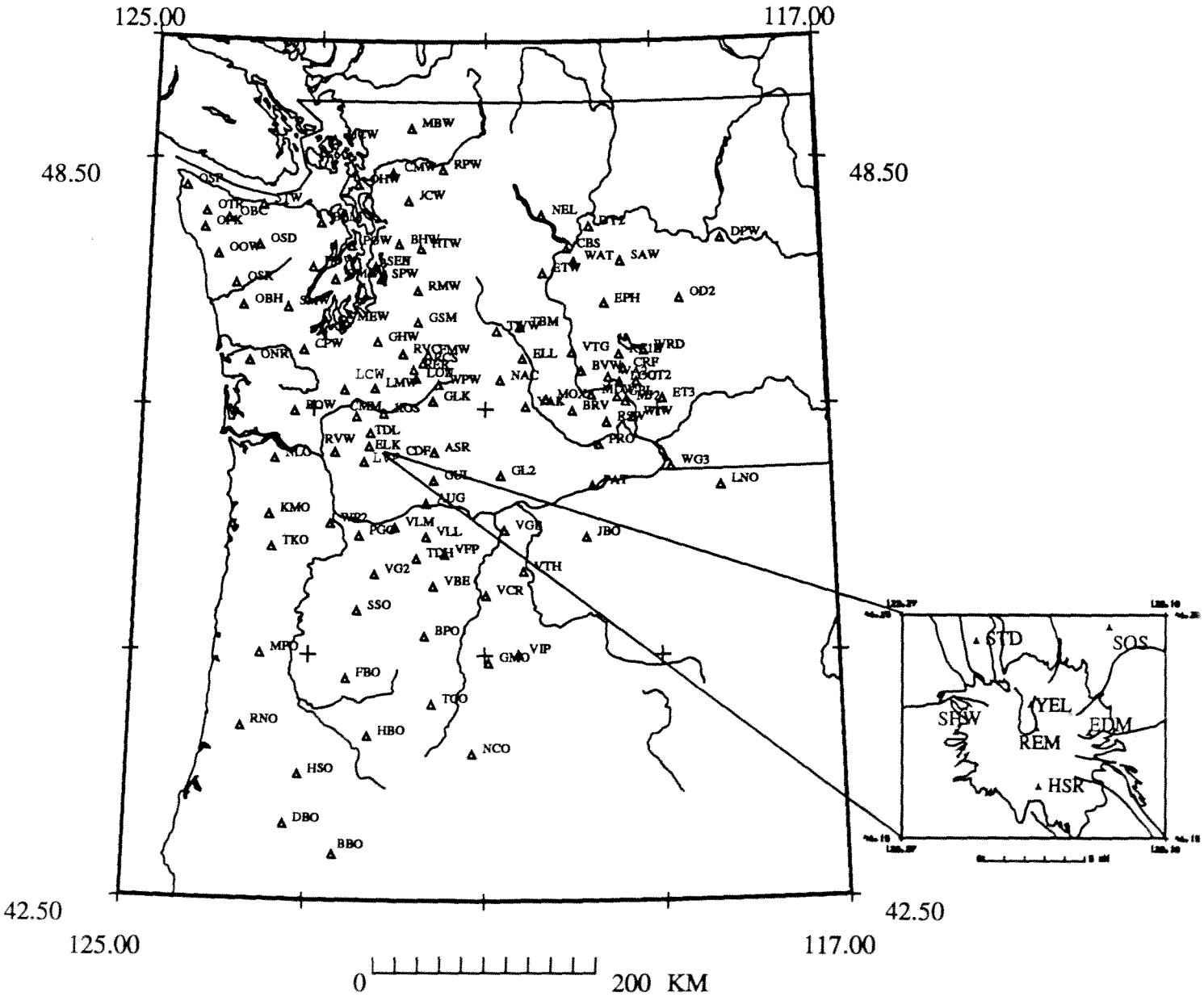

Figure 1: Stations operating at the end of the third quarter, 1992.

STATIONS USED FOR LOCATION OF EVENTS

Table 2 lists stations used in locating seismic events in Washington and Oregon. Stations marked by an asterisk (*) were supported by USGS joint operating agreement 1434-92-A-0964 Stations marked by (%) were supported by USGS joint operating agreement 1434-92-A-0963, and (+) indicates support under Westinghouse Hanford Company Contract MLR-SVV-666685 All other stations were supported from other sources.

The first column in the table gives the 3-letter station designator. This is followed by a symbol designating the funding agency, station north latitude and west longitude (in degrees, minutes and seconds), station elevation in km, and comments indicating landmarks for which stations were named.

TABLE 2

Stations Operating at the End of the Second Quarter 1992

STA	F	LAT	LONG	EL	NAME
ASR	%	46 09 02.4	121 35 33.6	1.280	Mt. Adams - Stagman Ridge
AUG	%	45 44 10.0	121 40 50.0	0.865	Augspurger Mtn
BBO	%	42 53 12.6	122 40 46.6	1.671	Butler Butte, Oregon
BHW	*	47 50 12.6	122 01 55.8	0.198	Bald Hill
BLN	*	48 00 26.5	122 58 18.6	0.585	Blyn Mt.
BOW	*	46 28 30.0	123 13 41.0	0.870	Boistfort Mt.
BPO	%	44 39 06.9	121 41 19.2	1.957	Bald Peter, Oregon
BRV	+	46 29 07.2	119 59 29.4	0.925	Black Rock Valley
BVW	+	46 48 30.6	119 52 48.0	0.707	Beverly
CBS	+	47 48 16.7	120 02 27.6	1.073	Chelan Butte, South
CDF	%	46 06 58.2	122 02 51.0	0.780	Cedar Flats
CMM	%	46 26 07.0	122 30 21.0	0.620	Crazy Man Mt.
CMW	*	48 25 25.3	122 07 08.4	1.190	Cultus Mtns.
CPW	*	46 58 25.8	123 08 10.8	0.792	Capitol Peak
CRF	+	46 49 30.6	119 23 18.0	0.260	Corfu
DBO	%	43 07 09.0	123 14 34.0	0.984	Dodson Butte, Oregon
DPW	+	47 52 14.3	118 12 10.2	0.892	Davenport
DY2	+	47 59 06.9	119 46 13.0	0.884	Dyer Hill 2
EDM		46 11 50.4	122 09 00.0	1.609	East Dome, Mt. St. Helens
ELK	%	46 18 20.0	122 20 27.0	1.270	Elk Rock
ELL	+	46 54 34.8	120 33 58.8	0.789	Ellensburg
EPH	+	47 21 12.8	119 35 46.2	0.628	Ephrata
ET3	+	46 34 37.0	118 56 11.0	0.305	Eltopia (replaces ET2)

continued

STA	F	LAT	LONG	EL	NAME
ETW	+	47 36 16.2	120 19 51.6	1.475	Entiat
FBO	%	44 18 35.6	122 34 40.2	1.080	Farmers Butte, Oregon
FL2	%	46 11 47.0	122 21 01.0	1.378	Flat Top 2
FMW	*	46 56 29.6	121 40 11.3	1.859	Mt. Fremont
GBL	+	46 35 51.6	119 27 35.4	0.330	Gable Mountain
GHW	*	47 02 30.0	122 16 21.0	0.268	Garrison Hill
GL2	+	45 57 35.0	120 49 22.5	1.000	New Goldendale
GLK	%	46 33 50.2	121 36 30.7	1.320	Glacier Lake
GMO	%	44 26 20.8	120 57 22.3	1.689	Grizzly Mountain, Oregon
GMW	*	47 32 52.5	122 47 10.8	0.506	Gold Mt.
GSM	*	47 12 11.4	121 47 40.2	1.305	Grass Mt.
GUL	%	45 55 27.0	121 35 44.0	1.189	Guler Mt.
HBO	%	43 50 39.5	122 19 11.9	1.615	Huckleberry Mt., Oregon
HDW	*	47 38 54.6	123 03 15.2	1.006	Hoodsport
HSO	%	43 31 33.0	123 05 24.0	1.020	Harness Mountain, Oregon
HSR	%	46 10 22.2	122 10 58.2	1.774	South Ridge, Mt. St. Helens
HTW	*	47 48 12.5	121 46 08.6	0.829	Haystack Lookout
JBO	+	45 27 41.7	119 50 13.3	0.645	Jordan Butte, Oregon
JCW	*	48 11 42.7	121 55 31.1	0.792	Jim Creek
JUN	%	46 08 48.0	122 09 10.8	1.049	June Lake
KMO	%	45 38 07.8	123 29 22.2	0.975	Kings Mt., Oregon
KOS	%	46 27 40.8	122 11 25.8	0.828	Kosmos
LCW	*	46 40 14.4	122 42 02.8	0.396	Lucas Creek
LMW	*	46 40 04.8	122 17 28.8	1.195	Ladd Mt.
LNO	+	45 52 15.8	118 17 06.0	0.768	Lincton Mt., Oregon
LO2	%	46 45 00.0	121 48 36.0	0.853	Longmire
LOC		46 43 04.8	119 25 54.6	0.201	Rohay Station
LVP	%	46 04 06.0	122 24 30.0	1.170	Lakeview Peak
MBW	*	48 47 02.4	121 53 58.8	1.676	Mt. Baker
MCW	*	48 40 46.8	122 49 56.4	0.693	Mt. Constitution
MDW	+	46 36 48.0	119 45 39.0	0.330	Midway
MEW	*	47 12 07.0	122 38 45.0	0.097	McNeil Island
MJ2		46 33 28.0	119 21 50.0	0.150	Rockwell Station
MOX	+	46 34 38.0	120 17 35.0	0.540	Moxie City
MPO	%	44 30 17.4	123 33 00.6	1.249	Mary's Peak, Oregon
MTM	%	46 01 31.8	122 12 42.0	1.121	Mt. Mitchell
NAC	+	46 43 59.4	120 49 25.2	0.728	Naches
NCO	%	43 42 14.4	121 08 18.0	1.908	Newberry Crater, Oregon
NEL	+	48 04 41.8	120 20 17.7	1.490	Nelson Butte
NLO	*	46 05 18.0	123 27 00.0	0.900	Nicolai Mt., Oregon
OBC	%	48 02 07.1	124 04 39.0	0.938	Olympics - Bonidu Creek
OBH	%	47 19 34.5	123 51 57.0	0.383	Olympics - Burnt Hill
OD2	+	47 23 27.6	118 42 38.4	0.590	Odessa site #2
OFK	%	47 57 00.0	124 21 28.1	0.134	Olympics - Forks
OHW	*	48 19 24.0	122 31 54.6	0.054	Oak Harbor

continued

STA	F	LAT	LONG	EL	NAME
ONR	%	46 52 37.5	123 46 16.5	0.257	Olympics - North River
OOW	%	47 44 12.0	124 11 22.0	0.743	Octopus West
OSD	*	47 49 15.0	123 42 06.0	2.010	Olympics - Snow Dome
OSP	%	48 17 05.5	124 35 23.3	0.585	Olympics - Sooes Peak
OSR	%	47 30 20.3	123 57 42.0	0.815	Olympics Salmon Ridge
OT2	+	46 43 17.0	119 14 05.0	0.355	New Othello (replaces OTH 12/1
OTR	%	48 05 00.0	124 20 39.0	0.712	Olympics - Tyee Ridge
PAT	+	45 52 50.1	119 45 40.1	0.300	Paterson
PGO	%	45 28 00.0	122 27 10.0	0.237	Gresham, Oregon
PGW	*	47 49 18.8	122 35 57.7	0.122	Port Gamble
PRO	+	46 12 45.6	119 41 09.0	0.552	Prosser
RC1E		46 56 36.0	119 26 00.0	0.500	Royal City,E-W comp
RC1N		46 56 36.0	119 26 00.0	0.500	Royal City,N-S comp
RC1Z		46 56 36.0	119 26 00.0	0.500	Royal City
RCS	*	46 52 15.6	121 43 52.0	2.877	Mt. Rainier, Camp Schurman
REM		46 11 57.0	122 11 03.0	2.102	Rembrandt (Dome station)
RER	*	46 49 09.2	121 50 27.3	1.756	Mt. Rainier, Emerald Ridge
RMW	*	47 27 35.0	121 48 19.2	1.024	Rattlesnake Mt. (West)
RNO	%	43 54 44.0	123 44 26.0	0.875	Roman Nose, Oregon
RPW	*	48 26 54.0	121 30 49.0	0.850	Rockport
RSW	+	46 23 28.2	119 35 19.2	1.037	Rattlesnake Mt. (East)
RVC	%	46 56 34.5	121 58 17.3	1.000	Mt. Rainier - Voight Creek
RVW	*	46 08 58.2	122 44 37.2	0.460	Rose Valley
SAW	+	47 42 06.0	119 24 03.6	0.690	St. Andrews
SEA		47 39 18.0	122 18 30.0	0.030	Seattle Wood-Andersons
SEE		47 39 18.0	122 18 30.0	0.030	Seattle Pseudo-WA (E)
SEN		47 39 18.0	122 18 30.0	0.030	Seattle Pseudo-WA (N)
SHW	*	46 11 50.6	122 14 08.4	1.399	Mt. St. Helens
SMW	*	47 19 10.2	123 20 30.0	0.840	South Mt.
SOS	%	46 14 38.5	122 08 12.0	1.270	Source of Smith Creek
SPW	*	47 33 13.3	122 14 45.1	0.008	Seward Park, Seattle
SSO	%	44 51 21.6	122 27 37.8	1.242	Sweet Springs, Oregon
STD	%	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
STW	*	48 09 02.9	123 40 13.1	0.308	Striped Peak
TBM	+	47 10 10.1	120 35 54.0	1.064	Table Mt.
TCO	%	44 06 21.0	121 36 01.0	1.975	Three Creek Meadows, Oregon.
TDH	%	45 17 23.4	121 47 25.2	1.541	Tom,Dick,Harry Mt., Oregon
TDL	%	46 21 03.0	122 12 57.0	1.400	Tradedollar Lake
TKO	%	45 22 16.7	123 27 14.0	1.024	Trask Mtn, Oregon
TWW	+	47 08 17.2	120 52 04.5	1.046	Teanaway
VBE	%	45 03 37.2	121 35 12.6	1.544	Beaver Butte, Oregon
VCR	%	44 58 58.2	120 59 17.4	1.015	Criterion Ridge, Oregon
VFP	%	45 19 05.0	121 27 54.3	1.716	Flag Point, Oregon
VG2	%	45 09 20.0	122 16 15.0	0.823	Goat Mt., Oregon
VGB	+	45 30 56.4	120 46 39.0	0.729	Gordon Butte, Oregon
VIP	%	44 30 29.4	120 37 07.8	1.731	Ingram Pt., Oregon

continued

STA	F	LAT	LONG	EL	NAME
VLL	%	45 27 48.0	121 40 45.0	1.195	Laurance Lk., Oregon
VLM	%	45 32 18.6	122 02 21.0	1.150	Little Larch, Oregon
VTG	+	46 57 28.8	119 59 14.4	0.208	Vantage
VTH	%	45 10 52.2	120 33 40.8	0.773	The Trough, Oregon
WA2	+	46 45 24.2	119 33 45.5	0.230	Wahluke Slope
WAT	+	47 41 55.0	119 57 15.0	0.900	Waterville
WG3	+	46 01 43.0	118 51 24.0	0.480	Wallula Gap
WIW	+	46 25 48.8	119 17 13.4	0.130	Wooded Island
WP2	%	45 33 57.2	122 47 06.9	0.341	West Portland, Oregon(replaces
WPW	%	46 41 53.4	121 32 48.0	1.250	White Pass
WRD	+	46 58 11.4	119 08 36.0	0.378	Warden
YAK	+	46 31 43.8	120 31 14.4	0.629	Yakima
YEL		46 12 35.0	122 11 16.0	1.750	Yellow Rock, Mt. St. Helens

EARTHQUAKE DATA

There were 975 events processed by the University of Washington digital recording seismic network between July 1 and September 30, 1992. Locations were determined for 627 of these in Washington and Oregon; 561 of these were classified as earthquakes and 66 as known or suspected blasts. The remaining 348 processed events include teleseisms (206 events), regional events outside the U. W. network (68), and unlocated events within the U. W. network. Unlocated events within the U.W. network include very small earthquakes and some known blasts. For example, only a few of the frequent mine blasts at Centralia are routinely processed.

Table 3 is the catalog of earthquakes and blasts located within the network for this quarter. Fig. 2 shows all earthquakes with magnitude greater than or equal to 0.0 ($M_c \geq 0.$) Fig. 3 shows blasts and probable blasts ($M_c \geq 0.$) Fig. 4 shows earthquakes located at Mt. Rainier ($M_c \geq 0$). Fig. 5 shows earthquakes located at Mt. St. Helens ($M_c \geq 0$).

Western Washington and Oregon

During the first quarter of 1992, 498 earthquakes were located between 42.5° and 49.5° north latitude and between 121° and 125° west longitude. Most of these occurred at depths less than 30 km with, as usual, a small number of earthquakes in the Puget Sound lowland and near the Olympic Peninsula at depths greater than 30 km. No earthquakes were reported felt in the western parts of Washington and Ore-

gon this quarter.

Eastern Washington and Oregon

During this quarter, 63 earthquakes were located in eastern Washington and Oregon, including 3 felt earthquakes. The largest of these was a magnitude M_c = 4.1 earthquake at 20:01 GMT on July 14. It was located about 9 km south of Walla Walla at a depth of 12 km, and was reported felt in the Walla-Walla area, and in the Oregon towns of Pendleton and Athena. A smaller felt earthquake at a depth of 6 km occurred at about the same spot on September 23 at 04:32 GMT. It had magnitude M_c = 2.8, and was reported felt by a few citizens in Walla-Walla. Two additional earthquakes during the quarter were located nearby but were not reported felt. During the final quarter of 1991, two felt earthquakes were located in the same area.

An earthquake on August 7 at 17:23 GMT with magnitude M_c = 3.9 and a very shallow depth (less than 1 km) located 40 km SSE of Prosser WA was reported felt at the Umatilla (Oregon) Army Depot, and in Boardman, Oregon.

Mount Rainier Area

There were 123 events in the region near Mt. Rainier, as seen in Fig. 5. Of these, 34 were located in what is called the 'western Rainier seismic zone', a north-south trending lineation of seismicity approximately 15 km west of the summit of Mt. Rainier. The rest were a combination of tectonic (14) and surficial events (50), with epicenters within 5 km of the summit. The remaining events were scattered around the cone of Rainier as seen in Fig. 5.

Activity at Mt. Rainier includes surface events (avalanches, rockfalls, ice quakes, etc.) and tectonic earthquakes. Events with very low frequency signals (1-3 Hz) believed to be icequakes are assigned type "L" in the catalog. Emergent, very long duration signals probably due to rockfalls or avalanches are assigned type "S". Shallow tectonic earthquakes have a higher frequency and presumably a different source. The number of events in close proximity to the cone of Mt. Rainier varies over the course of the year, since the source of much of the shallow surface-type activity is presumably ice movement or avalanching, which is seasonal in nature.

Mount St. Helens Area

In the third quarter, 156 events (tectonic or surficial) were located at Mt. St. Helens, with 25 earthquakes deeper than 4 km. The largest event occurred on August 16 at 23:05, at a depth of 1 km, with a magnitude of M_c = 2.8. Most of the events greater than magnitude 2, that appear to be located outside the crater in Fig. 5 are actually type "S", i.e. surficial events, which probably occurred within the crater. These events usually have emergent arrivals and are difficult to locate. Also, magnitudes for "S" type events may tend to be overestimated, because a surficial event typically has a longer coda than a tectonic earthquake with the same energy release.

Other Sources for Earthquake Information

In addition to this publication, information on recent earthquakes is available from several sources. Via computer, a non-interactive account on the University of Washington Geophysics Program computer with login name "quake" and password, "quake" provides the latest information about earthquakes worldwide (from the USGS National Earthquake Information Center) and for the Pacific Northwest (from the Washington Regional Seismograph Network). To receive this information by modem, dial (206) 685-0889 at either 1200 or 2400 baud or use "finger quake@geophys.washington.edu" on InterNet. We also provide automatic computer-generated alert messages by E-Mail or FAX to institutions needing such information, and we regularly exchange phase data via E-mail with other regional seismograph network operators. To request information by E-mail, contact rick@geophys.washington.edu.

Earthquake information in the quarterlies is published in final form by the Washington State Department of Natural Resources as information circulars entitled "Earthquake Hypocenters in Washington and Northern Oregon" covering the period 1970-1986 (see circulars #53,56,64-66,72,79,82-84). A catalog covering earthquakes in 1987-1989 is in preparation. These circulars, plus circular #85, "Washington State Earthquake Hazards", are available from Washington Dept. of Natural Resources, Division of Geology and Earth Resources, Post Office Box 47007, Olympia, Wa. 98504-7007, or by telephone at (206) 902-1450.

Other regional agencies provide earthquake information. These include the Geological Survey of Canada (Pacific Geoscience Centre, Sidney, B.C. FAX (604) 363-6565), which produces monthly sum-

maries of Canadian earthquakes; the United States Geological Survey which produces weekly reports called "Seismicity Reports for Northern California" (USGS, attn: Steve Walter, 345 Middlefield Rd, MS-977, Menlo Park, Ca, 94025) and "Weekly Earthquake Report for Southern California" (USGS, attn: Dr. Kate Hutton or Dr. Lucy Jones, California Institute of Technology, Pasadena, Ca.)

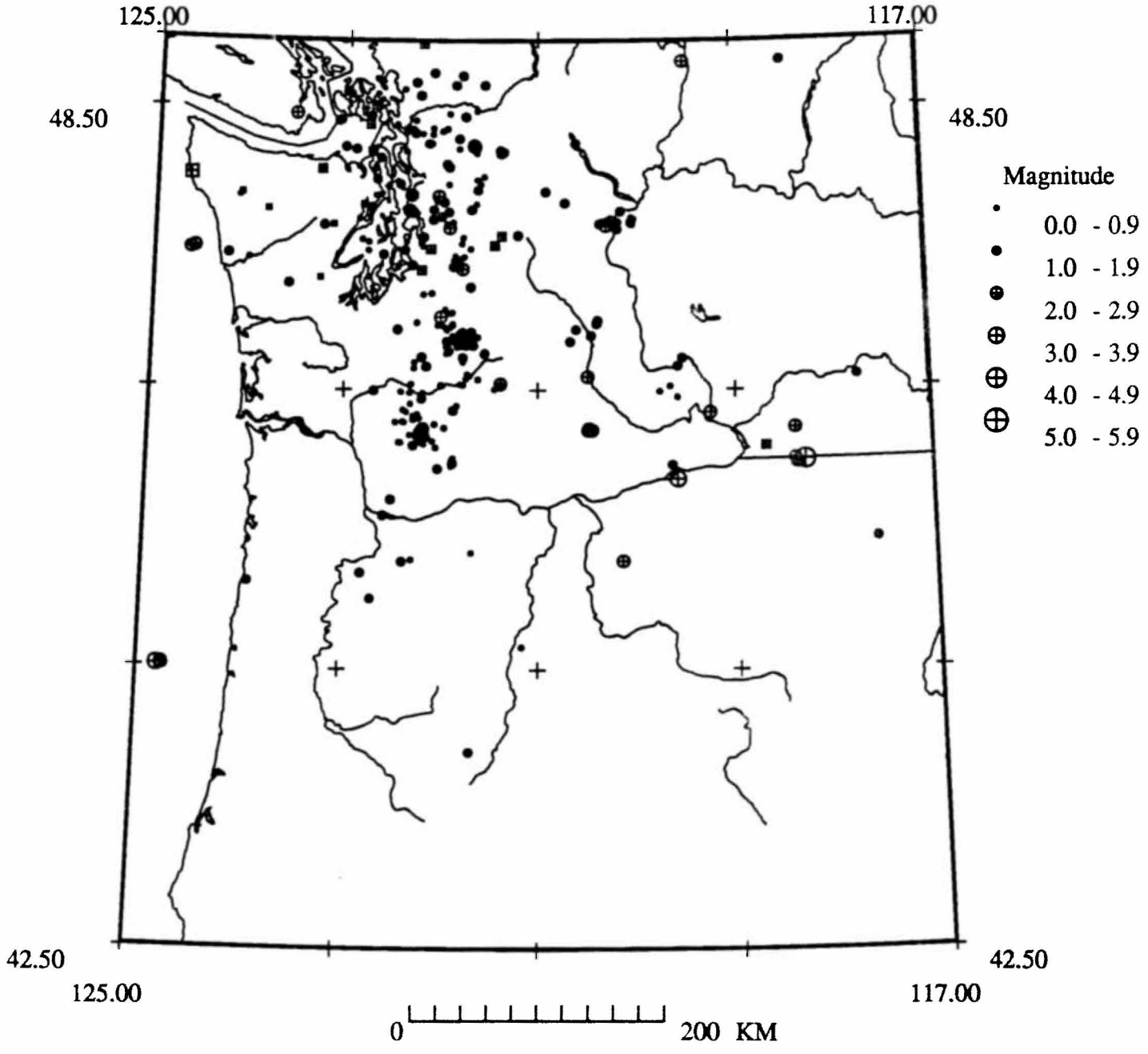

Figure 2: Earthquakes located in Washington and Oregon with magnitudes greater than or equal to 0.0 during the third quarter of 1992. Square symbols indicate events located at depths of 30 km or more.

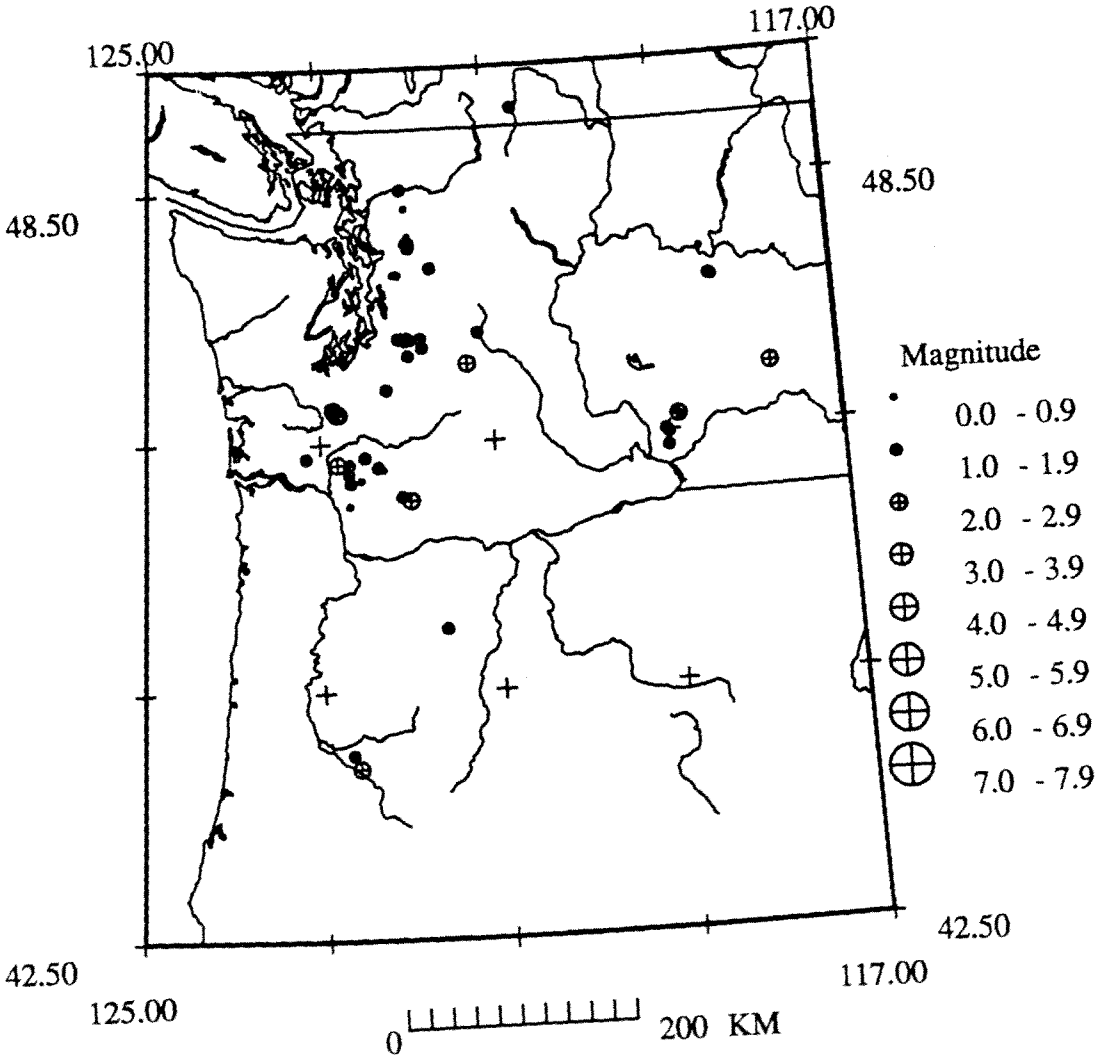

Figure 3: Blasts and probable blasts, third quarter, 1992.

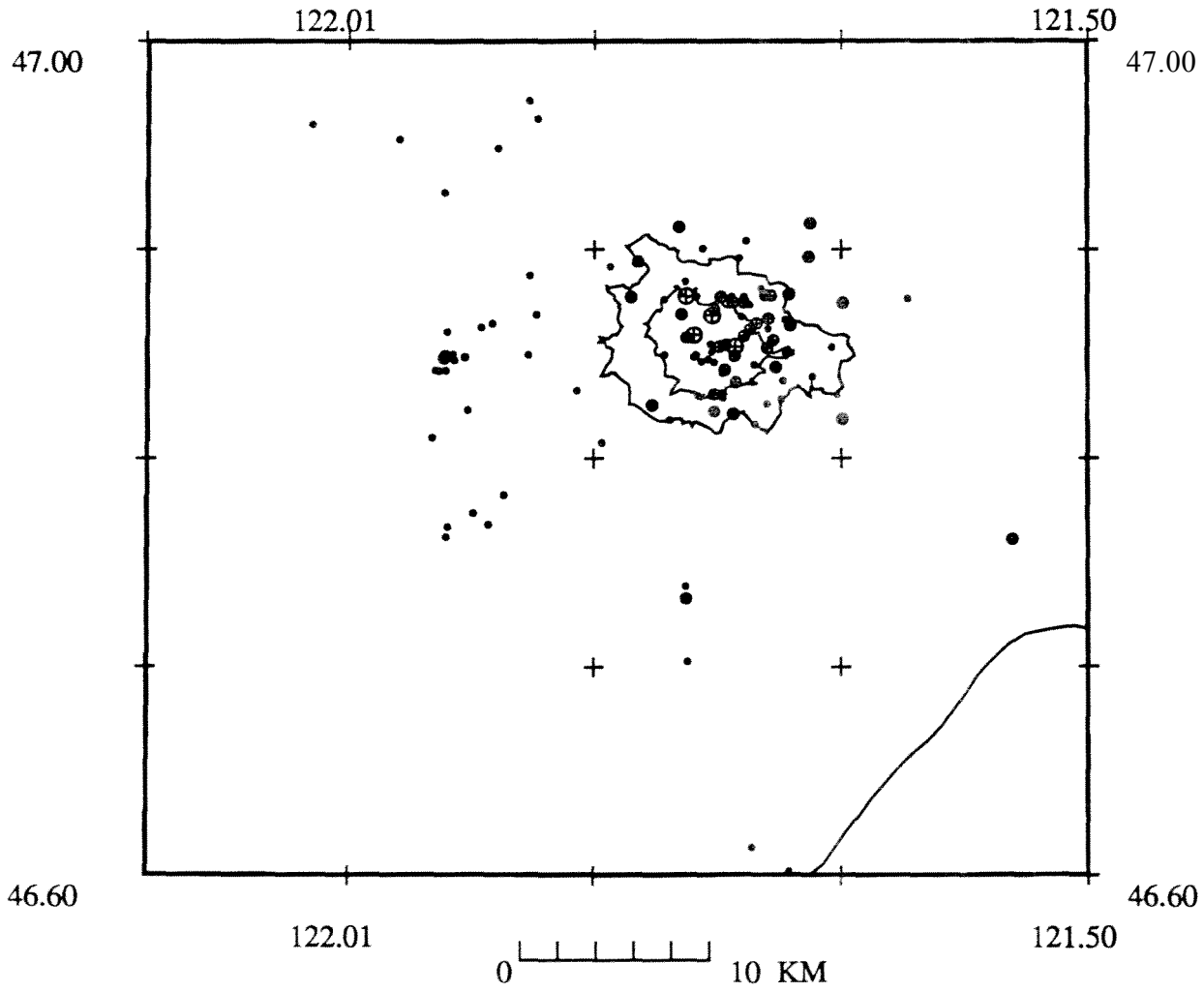

Figure 4: Earthquakes located in the Mt. Rainier area third quarter, 1992. All events are greater than 0.0. Inner contour is the 10,000 foot elevation contour, and the outer is the 7,500 foot contour.

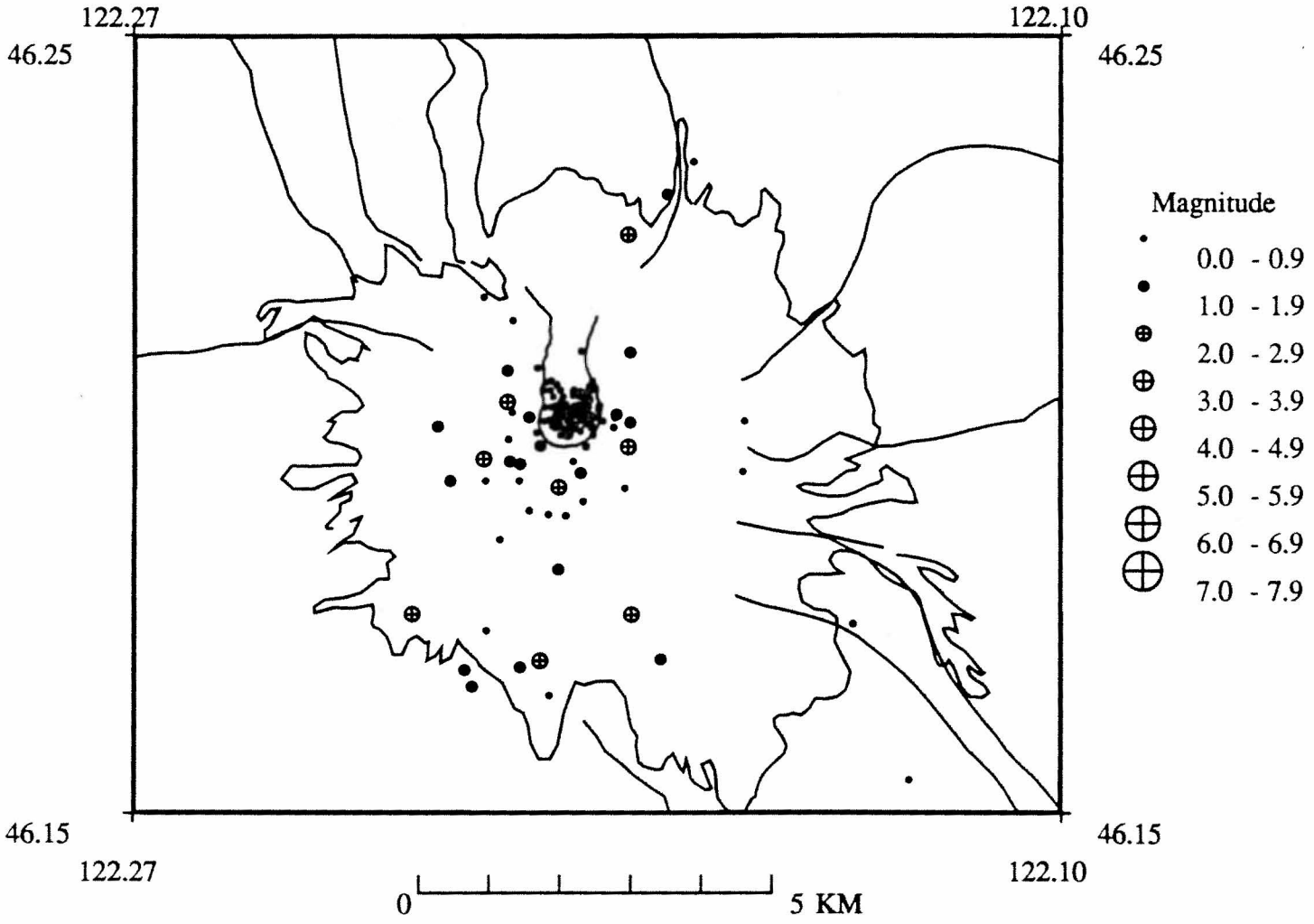

Figure 5: Earthquakes located in the Mt. St. Helens area during the third quarter, 1992. All events were shallower than 30 km.

Key to Earthquake Catalog in Table 3

TIME Origin time is calculated for each earthquake on the basis of multistation arrival times. Time is given in **Coordinated Universal Time** (UTC), in hours:minutes:seconds. To convert to Pacific Standard Time (PST) subtract eight hours, or to Pacific daylight time subtract seven hours.

LAT North latitude of the epicenter, in degrees and minutes.

LONG West longitude of the epicenter, in degrees and minutes.

DEPTH The depth, given in kilometers, is usually freely calculated 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.

MAG Coda-length magnitude M_c. An estimate of local Richter magnitude (Richter, C.F., 1958, Elementary Seismology: W.H. Freeman and Co., 768p), calculated using the coda-length/magnitude relationship determined for Washington (Crosson, R.S., 1972, Bull. Seism. Soc. Am., v. 62, p. 1133-1171). Where blank, data were insufficient for a reliable magnitude determination. Normally, the only earthquakes with undetermined magnitudes are very small ones. Magnitudes may be revised as we improve our analysis procedure.

NS/NP **NS** is the number of station observations, and **NP** the number of P and S phases used to calculate the earthquake location. A minimum of three stations and four phases are required. Generally, more observations improve the quality of the solution.

GAP Azimuthal gap. The largest angle (relative to the epicenter) containing no stations.

RMS The root-mean-square residual (observed arrival time minus predicted arrival time) at all stations used to locate the earthquake. It is only useful as a measure of the quality 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.

Q Two **Quality factors** indicate 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 is a measure of the hypocenter quality based on travel time residuals. For example: **A** quality requires an **RMS** less than 0.15 sec while 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, 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, **NP** , is 5 or less or **GAP** > 180° or **DMIN** > 50 km the solution is assigned quality **D.**

MOD The crustal velocity model used in location calculations.

P3 - Puget Sound model
C3 - Cascade model
S3 - Mt. St. Helens model including Elk Lake
N3 - northeastern model
E3 - southeastern model
O0 - Oregon model

TYP Events flagged in Table 3 use the following code:

F - earthquakes reported to have been felt
P - probable explosion
L - low frequency earthquakes
H - handpicked from helicorder records
S - Special, non-tectonic event (eg. rockslides, avalanches)
X - known explosion

Articles and Reports:

Benson, R., C.D. Lindholm, R.S. Ludwin, and A.I. Qamar, (in press), A Method for Identifying Explosions Contaminating Earthquake catalogs: Application to the Washington Regional Earthquake Catalog, Seis. Res. Lett.

Jonientz-Trisler, C. B. Myers, and J. Power, (in preparation), Seismic identification of gas-and-ash explosions at Mount St. Helens: capabilities, limitations, and regional application, in /fIProceeding Volume, First International Symposium on Volcanic Ash and Aviation Safety,/fR USGS Bulletin 2047.

Ludwin, R.S., A.I. Qamar, S.D. Malone, C. Jonientz-Trisler, R.S. Crosson, R. Benson, and S. Moran (in preparation), Earthquake Hypocenters in Washington and Northern Oregon, 1987-1989, Washington State Dept. of Natural Resources.

Ludwin, R. S., S.D. Malone, R.S. Crosson, A.I. Qamar, (in press or submitted), Washington Earthquakes 1986, Washington Earthquakes 1987, Washington Earthquakes 1988, Washington Earthquakes 1989, in U.S. Earthquakes

Swanson, D.A, S.D. Malone, and B.A. Samora, 1992, Mount Rainier: A Decade Volcano, EOS, V. 73, No. 16, p. 177.

Univ. of Wash. Geophysics Program, 1992, Quarterly Network Report 91-D on Seismicity of Washington and Northern Oregon

Univ. of Wash. Geophysics Program, 1992, Quarterly Network Report 92-A on Seismicity of Washington and Northern Oregon

Univ. of Wash. Geophysics Program, 1992, Quarterly Network Report 92-B on Seismicity of Washington and Northern Oregon

Univ. of Wash. Geophysics Program, 1992, Quarterly Network Report 92-C on Seismicity of Washington and Northern Oregon

Abstracts

Crosson, R.S., M.J. Woolf, and G.C. Thomas, 1992, The SNAPS automated regional network processing system; experience and performance on the Washington Regional Seismograph Network, EOS, Vol. 73, No. 43, p. 72.

Jonientz-Trisler, C. B. Myers, and J. Power, 1991, Seismic identification of gas-and-ash explosions at Mount St. Helens: capabilities, limitations, and regional application, in *First International Symposium on Volcanic Ash and Aviation Safety,* USGS Circular 1065, Program and Abstracts, Seattle WA, July 8 through 12, 1991.

Malone, S.D., 1992, The Washington Regional Seismograph Network response to large seismic events, EOS, V. 73, No. 43, p. 69.

Malone, S.D., (in press, Invited), Pacific Northwest earthquake hazards based on Historic seismicity, Report of the National Earthquake Prediction Evaluation Council, May 7-8, 1992.

Moran, S. C., S. D. Malone and S. E. Barker, 1991, Deep earthquakes at Mount St. Helens: evidence for a collapsing and dilating magma chamber, EOS, V. 72, p. 523.

Qamar, A.I. and R.S. Ludwin, 1992, Stress directions in Washington and Northern Oregon inferred from earthquake focal mechanisms, Seis. Res. Lett., V. 63, No. 1, p. 28 (also in GSA 88th Annual Cordilleran Section, 1992 Abstracts with Programs, V. 24(5)).

Theses

Moran, S. C., 1992, Mount St. Helens, 1980-1992: The dynamics and evolution of an active magmatic system as inferred from earthquakes and focal mechanism, Master's thesis, Geophysics Program, Univ. of Wash., Seattle, WA.