FINAL TECHNICAL REPORT: 1991

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Final Technical Report for USGS Joint Operating Agreements 14-08-0001-A0622 Regional Seismic Monitoring in Western Washington and 14-08-0001-A0623 Seismic Monitoring of Volcanic and Subduction Processes in Washington and Oregon

Summary

This is the final technical report for USGS Joint Operating Agreements 14-08-0001-A0622 'Regional Seismic Monitoring in Western Washington' and 14-08-0001-A0623 'Seismic Monitoring of Volcanic and Subduction Processes in Washington and Oregon'. 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 the operating agreement period.

Operations

Twenty-eight stations covering much of western Washington are supported under JOA A0622. Fifty-one stations covering the Olympic Peninsula, volcanos in the central Cascades, and much of western Oregon are supported under JOA A0623. 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 1990 through September 1991 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.

During 1991 we installed 4 new stations in Oregon. These stations, SSO, FBO, WMO and RNO were installed in August and September, and are supported under 14-08-0001-A0623. These stations are telemetered to Oregon State Department of Transportation microwave links, which we use to relay the signals to the Bonneville Power Administration (BPA) site in Portland. From the BPA in Portland, the signal is telemetered by microwave to Seattle, and thence by phone lines to the UW. Also in Oregon, station GRO was removed, resited, and renamed TKO. Station YEL, in the crater of Mt. St. Helens, was damaged in February by a steam emission and is still inoperable. Station APW, south of the Puget Basin, was removed in March due to the explosions in a nearby gravel quarry. We plan to either reinstall or resite both YEL and APW.

Stations supported under USGS JOAs A0622 and A0623, 1991

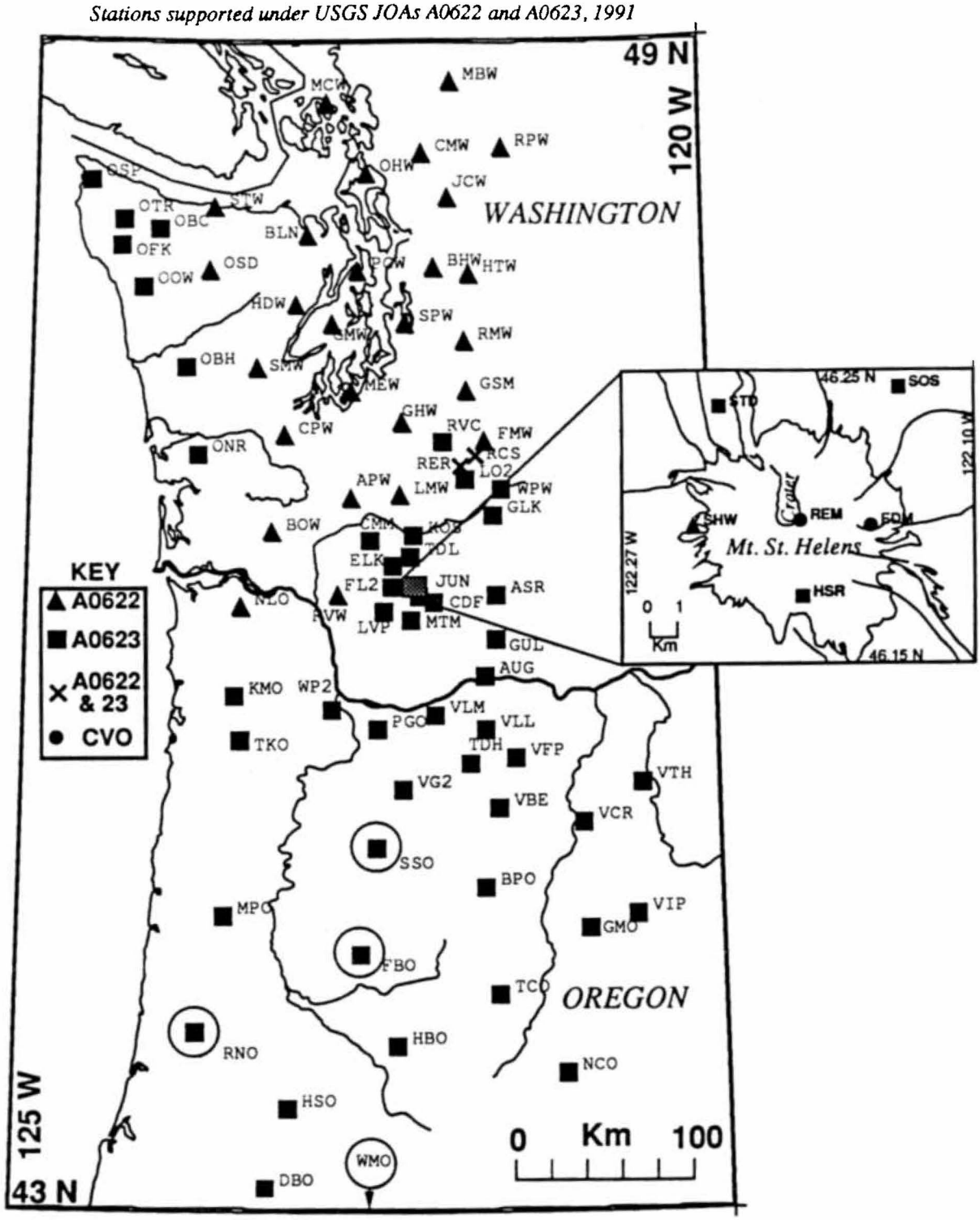

Figure 1. Map view of seismic stations supported under USGS JOA A0622 and A0623 between Nov. 1, 1990 and Oct. 31, 1991. Twenty-eight stations supported under JOA A0622 (triangular symbols) provide coverage of the Mount Baker, Glacier Peak and Mt. Rainier volcanos and western Washington, while 51 stations supported under JOA A0623 (square symbols) cover the Olympic Peninsula and Cascade Mountains, including Mount St. Helens and other Cascade volcanos into central Oregon. Stations RCS and RER (operated jointly under A0622 and A0623) are shown as "x" symbols. One station, WMO (not shown), is located just south of the area shown.

TABLE 1

Stations supported under USGS Joint Operating Agreement A0622

NAME	LAT	LONG	ELEV(km)	LOCATION
APW	46 39 06.0	122 38 51.0	0.457	Alpha Peak
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 12.5	121 46 08.6	0.829	Haystack Lookout
JCW	48 11 42.7	121 55 31.1	0.792	Jim 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 18.0	123 27 00.0	0.900	Nicolai Mt., Oregon
OHW	48 19 24.0	122 31 54.6	0.054	Oak Harbor
OSD	47 49 15.0	123 42 06.0	2.010	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 58.2	122 44 37.2	0.460	Rose Valley
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.
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 A0623

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
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	Grizzlie 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
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
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(replaces
WPW	46 41 53.4	121 32 48.0	1.250	White Pass

TABLE 3
Stations supported jointly by USGS JOAs A0622 and A0623

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

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@geophysics.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 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 monitored seismicity and moment release at Cascade Volcanos, provided information for the public, and collected intensity reports for felt earthquakes. Rick Benson prepared the quarterly reports, provided routine analysis and archiving of digital trace data. Shawn Dewberry, Kim Edlund, Seth Moran, Jiang Yan, and John VanDecar assisted with processing and archiving of earthquake data. 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. We particularly appreciate the cooperation of the Oregon Dept. of Transportation during the installation of stations in Oregon.

QUARTERLY NETWORK REPORT 90-D

on

Seismicity of Washington and Northern Oregon

October 1 through December 31, 1990

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

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INTRODUCTION

This is the fourth quarterly report of 1990 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 shows major geographical features in the state of Washington and northern Oregon and 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.

There were no new stations added to the network this quarter. There was, however, one station lost to a volcanic explosion at Mt. St. Helens on November 5. Station YEL was hit by debris resulting from a steam explosion. YEL is located within a kilometer of the dome within the crater of Mt. St. Helens.

During the quarter, repair work was undertaken on the roof facility at the University of Washington, and as a result, 24 stations from Western Washington were down the weekend Oct 20 to Oct 22.

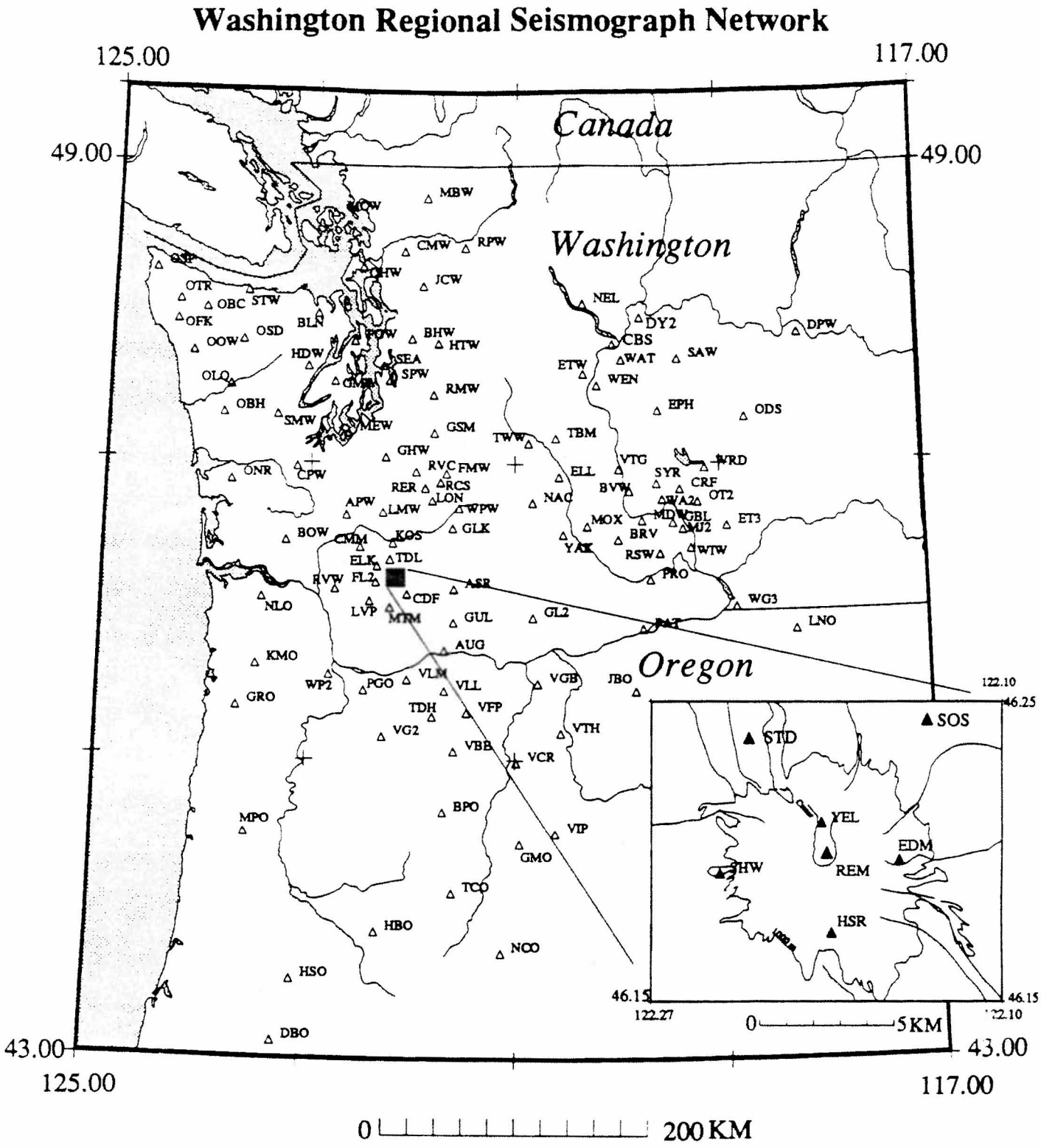

Figure 1. Seismograph stations operating during the fourth quarter 1990.

TABLE 1
Station Outages 4th quarter 1990

Station	Outage Dates	Comments
APW	Oct 20-Oct 22	Dead;roof power supply
BHW	Oct 20-Oct 22	Dead;roof power supply
BLN	Oct 20-Oct 22	Dead;roof power supply
BOW	Oct 20-Oct 22,Dec 3-Dec 7	Roof power, and blown txmitter;water damage
CDF	Dec 28-End	Dead
CMW	Oct 20-Oct 22,Nov 16-End	Roof power, then dead
CPW	Oct 20-Oct 22	Dead;roof power supply
EDM	Dec 28-End	Dead
ELL	Nov 1-Nov 11	Replaced radio pair,off center freq.
EPH	Oct 17-Oct 21	Dead
FMW	Oct 20-Oct 22, Dec 25-Dec 26	Roof power, then dead
GHW	Oct 20-Oct 22	Dead;roof power supply
GMW	Oct 20-Oct 22	Dead;roof power supply
GRO	Oct 1-End	Off center freq, pulled 12/4
HBO	Oct 24-Oct 30	Bad summing amp
HDW	Oct 20-Oct 22	Dead;roof power supply
HSO	Oct 10-Oct 30	Intermittent
HSR	Dec 28-End	Dead
HTW	Oct 20-Oct 22	Dead;roof power supply
JUN	Oct 1-Oct 9	Dead
LMW	Oct 20-Oct 22	Dead;roof power supply
LNO	Nov 21-???	Dead
MEW	Oct 20-Oct 22	Dead;roof power supply
MTM	Dec 28-End	Dead
NLO	Dec 1-Dec 6	Marginal reception, water damage in antenna cable
OD2	Dec 5-Dec 7	Wind damaged antenna
ODS	Oct 17-Oct 21	Dead
PGO	Nov 29-Nov 4	Dead
PGW	Oct 20-Oct 22	Dead;roof power supply
RCS	Oct 20-Oct 22	Dead;roof power supply
RER	Oct 20-Oct 22	Dead;roof power supply
RMW	Oct 20-Oct 23	Dead;roof power supply, didn't come up with rest
RPW	Oct 20-Oct 22	Dead;roof power supply
RVC	Oct 20-Oct 22	Dead;roof power supply
RVW	Oct 20-Oct 22	Dead;roof power supply
SHW	Oct 20-Oct 22	Dead;roof power supply
SMW	Oct 1-Oct 31	Dead
STW	Oct 20-Oct 22	Dead;roof power supply
TBM	Nov 1-Nov 6	Replaced radio pair
TCO	Oct 1-Oct 31	Bad seis?
TDH	Oct 25-End	Dead
VCR	Oct 15-Oct 22	No subcarrier
VG2	Nov 19-Dec 4	Replaced radio pair
VGB	Nov 12-Nov 19	No subcarrier
VLM	Oct 10-Oct 15,Nov 1-Nov 16	Dead
WRD	Oct 17-Oct 21	Dead
YEL	Nov 5-End	Dead; volcanic explosion

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 Fourth Quarter 1990

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 (replaces ET2)
ETW	+	47 36 16.2	120 19 51.6	1.475	Entiat
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	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.
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	Linton 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 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
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	-	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	-	New 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
PGO	$	45 28 00.0	122 27 10.0	0.237	Gresham, Oregon

continued

STA	F	LAT	LONG	EL	NAME
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)
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
STD	$	46 14 16.0	122 13 21.9	1.268	Studebaker Ridge
STW	*	48 09 02.9	123 40 13.1	.308	Striped Peak
TBM	+	47 10 10.1	120 35 54.0	1.064	Table Mt.
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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
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
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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
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VLL	$	45 27 48.0	121 40 45.0	1.195	Laurance Lk., Oregon
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WA2	+	46 45 24.2	119 33 45.5	.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
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 1069 events processed by the University of Washington digital recording seismic network between October 1 and December 31, 1990. Locations were determined for 503 of these in Washington and Northern Oregon; 434 were classified as earthquakes and 69 as known or suspected blasts. The remaining 566 processed events include teleseisms (204 events), regional events outside the U. W. network (32), 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 Mount St. Helens ($M_c \geq 0$). Fig. 5 shows earthquakes located at Mount Rainier ($M_c \geq 0$).

Western Washington and Oregon

During the fourth quarter of 1990, 434 earthquakes were located between 43.0° 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 at depths greater than 30 km.

During the fourth quarter, there were two small earthquakes reported felt in western Washington and Oregon. The first occurred on October 19 near Mt. Hood, Oregon. This was a $M_c = 3.5$ earthquake located 4 km SSE of the summit of Mt. Hood, and felt in Government Camp and at Timberline Lodge on the flanks of the mountain. It had a depth of approximately 6 km. There was no damage. This earthquake was one of 24 to have occurred during a swarm of activity which continued over a three hour period on the 19th. Activity such as this is not unusual on Mt. Hood, where rather intense activity can occur for short periods of time, followed by many months of quiescence. Of these 24 earthquakes, all but two were smaller than $M_c = 1.7$.

The second felt event occurred on Dec 30, and also was $M_c = 3.5$. This located approxi-

mately 3 km southwest of North Bend, was 17 km deep, and was felt in North Bend and the Wilderness Rim area. There was no reported damage.

Eastern Washington and Oregon

This quarter, there were only 30 earthquakes located in Eastern Washington. The most notable activity was concentrated near the town of Beverly, Wa. Beverly is located 50 km southeast of Ellensburg on the Columbia River, in the Saddle Mountains area. There was a cluster of six earthquakes located between December 15 and December 22, beginning with a $M_c = 3.1$ on December 15. The largest was a $M_c = 3.4$ on December 22. The smallest earthquake was a $M_c = 1.5$ on December 21. None of these were felt, and all were less than 5 km in depth.

There continued to be very few earthquakes in the Entiat area, near the most southern tip of Lake Chelan. Only seven earthquakes occurred during the quarter. There were only five last quarter. Rates such as this are anomolously low, when compared to rates over the last twenty years, as reported last quarter.

Mount Rainier Area

Since early in 1989, we have been reporting activity near Mt. Rainier. This is primarily due to the fact that our ability to locate earthquakes has improved, and we feel the steady earthquake activity in the area is worth mention. Starting this quarter, Mt. Rainier seismicity will be summarized on a regular basis with an accompanying seismicity map, (Figure 4), as is done for Mt. St. Helens, (Figure 5).

There were 65 events within the vicinity of the cone of Mt. Rainier, among a total of 97 events within the region seen in Fig. 5. As a measure of comparison, there were only 28 events near the cone last quarter. The term 'near' is used here to discriminate between events in close proximity to the cone and those further than approximately 10 km away. Activity at Mt. Rainier is of many types, including surface events (avalanches, ice quakes, etc.) and tectonic earthquakes. Events in the catalog, in this area, and flagged with type "L" for low frequency, are generally surface-type, to discriminate them from the shallow tectonic earthquakes, which have a higher

frequency and a different source. The number of events in close proximity to the cone of Mt. Rainier can be expected to vary over the course of the year, because the source of much of the shallow surface-type activity is ice movement or avalanching, which is seasonal in nature.

An unusual period of activity occurred on Mt. Rainier this quarter which differs from any activity previously recorded. Starting on October 18, very small, low frequency events began to appear on monitoring stations on the flanks of the mountain. (Stations RCS and RER). The unusual aspect of these events is that they were essentially "clones" of one another in all respects. They have the same seismic signature, meaning they look virtually identical. There was very little deviation in the rate of approximately one event per hour until October 24, when they began to slow somewhat. On October 24, a bulletin was issued to government agencies which in the past have had an interest in knowing when unusual activity was occurring, including the USGS and the Mt. Rainier National Park Service. These events were considered no more than a scientific curiosity and not considered dangerous in a volcanic sense. Activity continued at a somewhat reduced rate until November 2, and have become less frequent towards the end of the quarter.

Mount St. Helens Area

168 events were located at Mt. St. Helens this quarter. This quarter, 40 were below a depth of 4 km, and the rest were relatively shallow. 4 km separates events in the very shallow crust and volcanic edifice from those within the deeper magmatic system. There were only two earthquakes which had magnitudes greater that 2.

Aside from this normal activity, there were two explosive events. The first occurred on November 5, and was responsible for the destruction of two seismic stations (YEL, operated by the Univ. of Washington, and GDN, which is a USGS operated station and not telemetered to the University of Washington). Dome blocks up to about two meters in diameter were scattered over the lower part of the west crater wall, northwest of the dome. This apparently was the result of an avalanche triggered by the explosion, and it was the avalanche that was apparently responsible for the damage to the equipment. The other event occurred on December 20, and was similar, but did not damage any equipment.

These explosive events are among a family of small explosive events that have occurred on the dome since August 1989. They are different than 'eruptive' episodes which have come to be associated with magmatic material being extruded, are 'constructive' in the sense of adding material to the dome, and have a great deal of accompanying seismicity. (The last episode like this occurred in 1986). These very unpredictable explosive events are called phreatic eruptions, have no precursory seismicity, have an effect only within the crater, are likely to recur, and can be thought of as 'destructive' in their ability to damage the dome.

QUARTERLY NETWORK REPORT 91-A

on

Seismicity of Washington and Northern Oregon

January 1 through March 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

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INTRODUCTION

This is the first 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.

There were no new stations added to the network this quarter. As reported last quarter, station YEL was lost in a phreatic explosion. Another station, REM, was temporarily lost on February 5 during a similar event. The antenna was bent during the event, and was straightened on February 12, only to be damaged again on February 14 during another explosion event. It was repaired again on February 24. It is not clear whether station YEL can be fixed safely, given the uncertain nature of these explosions.

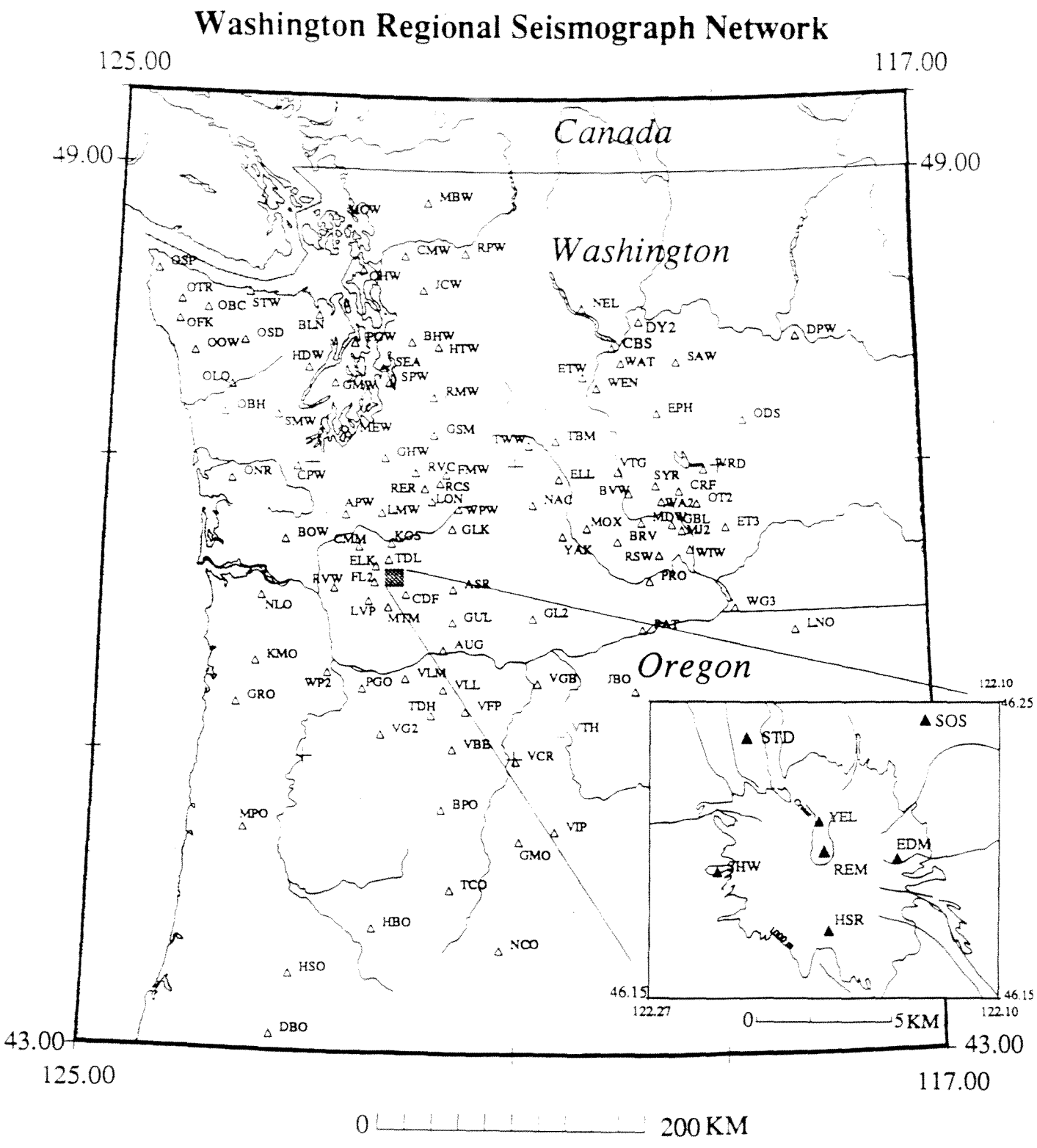

Figure 1. Seismograph stations operating during the first quarter 1991.

TABLE 1
Station Outages 1st quarter 1991

Station	Outage Dates	Comments
APW	March 21-End	Station removed during excavation work
CDF	Jan 1-Jan 4,Jan 8-March 20	Receiver at WP2 tuned,then intermittent
CMW	All period	Dead
EDM	Jan 1-Jan 4,Jan 8-March 20	Receiver at WP2 tuned,then intermittent
ELK	Jan 1-Jan 21	Recv'r bad at ELK
ELL	Jan 1-Jan 18	Dead;VCO problem
GRO	All period	Dead
HBO	Feb 19-Feb 23	Dead
HDW	Jan 9-Jan 10	Dead
HSR	Jan 1-Jan 4,March 3-March 26	Receiver at WP2 tuned,fixed at site
LO2	March 12-March 13	Dead
LON	March 12-March 13	Dead
MTM	Jan 1-Jan 4,Jan 8-March 20	Receiver at WP2 tuned,then intermittent
NCO	March 27-End	Dead
OBH	March 1-End	Aseismic
OSD	Jan 14-Jan 16	Dead
REM	Feb 5-Feb 12,Feb 14-End	Died in 2 successive volcanic explosions
SHW	Feb 2-Feb 4	Xtalks with MCW
SMW	Feb 15-March 4	Dead
SOS	Jan 1-Jan 21	Recv'r bad at ELK;intermittent
SPW	Jan 1-Jan 29	Bad phone cable
STD	Jan 1-Jan 21	Recv'r bad at ELK;intermittent
TDH	All period	Dead
VGB	Jan 1-Jan 18	Bad VCO, replaced
VTH	Jan 1-??	Dead, came back w/o repair
YAK	Jan 10-Jan 14	Dead, fixed w/o site visit

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 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 (replaces ET2
ETW	–	47 36 16.2	120 19 51.6	1.475	Entiat
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 15 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.
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	Linton 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 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
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	-	New 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
PGO	$	45 28 00.0	122 27 10.0	0.237	Gresham, Oregon

continued

STA	F	LAT	LONG	EL	NAME
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)
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
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
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
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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
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 631 events processed by the University of Washington digital recording seismic network between January 1 and March 31, 1990. Locations were determined for 424 of these in Washington and Northern Oregon; 360 were classified as earthquakes and 64 as known or suspected blasts. The remaining 207 processed events include teleseisms (107 events), regional events outside the U. W. network (21), 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 first quarter of 1991, 324 earthquakes were located between 43.0° 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 at depths greater than 30 km.

During the first quarter, there were three small earthquakes reported felt in western Washington and Oregon. The first occurred on January 25 near Deming, Wa. This was a shallow (<5 km deep) event with a $M_c = 2.8$. This area has experienced some of the most intense seismic activity in the state the last few years, so earthquakes which are small are often reported. This would explain why the very small earthquake on January 19 was also reported as having been felt, even though it had a magnitude of only 1.4. It occurred in the same place, and was also shallow.

The only other felt event occurred 28 km north of Portland, Oregon. It was approximately 20 km deep, and had a $M_c = 3.1$. This event, like the previous events, caused no damage.

Eastern Washington and Oregon

This quarter, there were 36 earthquakes located in Eastern Washington. For the first time in many quarters, the most notable activity was centered around the town of Entiat, Wa. This area has experienced rather continuous activity for the last twenty years. This quarter saw the first felt earthquake in this area in four years, when on March 28, a $M_c = 3.3$ occurred. It was less than 2 km in depth. It caused no damage. One other earthquake was felt, this one 15 km north of the town of Chelan, Wa. This event was a $M_c = 3.1$ on February 14, had a depth of 8 km, and caused no damage either.

Mount Rainier Area

There were 48 events in the region near Mt. Rainier, as seen in Fig. 5. This is down from the 97 events reported last quarter, primarily due to the fact that "clone" events ceased to be recorded and located. These low frequency, identical looking events which were reported last quarter essentially stopped last November.

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

123 events were located at Mt. St. Helens this quarter. There were only two earthquakes which had magnitudes greater that 2, the same as last quarter. This quarter, 33 earthquakes were deeper than 4 km, and the rest were shallower. 4 km separates events in the very shallow crust and volcanic edifice from those within the deeper magmatic system.

Like last quarter, there were two explosive events. The first occurred on February 5, and was responsible for a plume of ash and steam to about 18,000 ft in altitude. Another explosion

occurred on February 14. Based upon seismogram records, it was roughly the same size as the February 5th event, although no estimation of plume size is available due to poor weather. Unfortunately, these explosions damaged two seismic stations, just like those that occurred in the fall. This time, station REM was damaged during the February 5 event, when the antenna was bent by debris. This station was brought back online on February 12, only to be damaged again on February 14. It was fixed again on February 24. Station GDN, likewise, was lost during the February 14 event. (GDN is a USGS operated station and not telemetered to the University of Washington).

These events are among a family of small explosive events that have occurred on the dome since August 1989. They are different than 'eruptive' episodes which have come to be associated with magmatic material being extruded, which are 'constructive' in the sense of adding material to the dome, and which have a great deal of accompanying seismicity. (The last episode like this occurred in 1986.) Since August of 1989, we have recorded these very unpredictable explosive events. These are phreatic eruptions, have no precursory seismicity, are likely to recur, and can be thought of as 'destructive' in their ability to damage the dome.

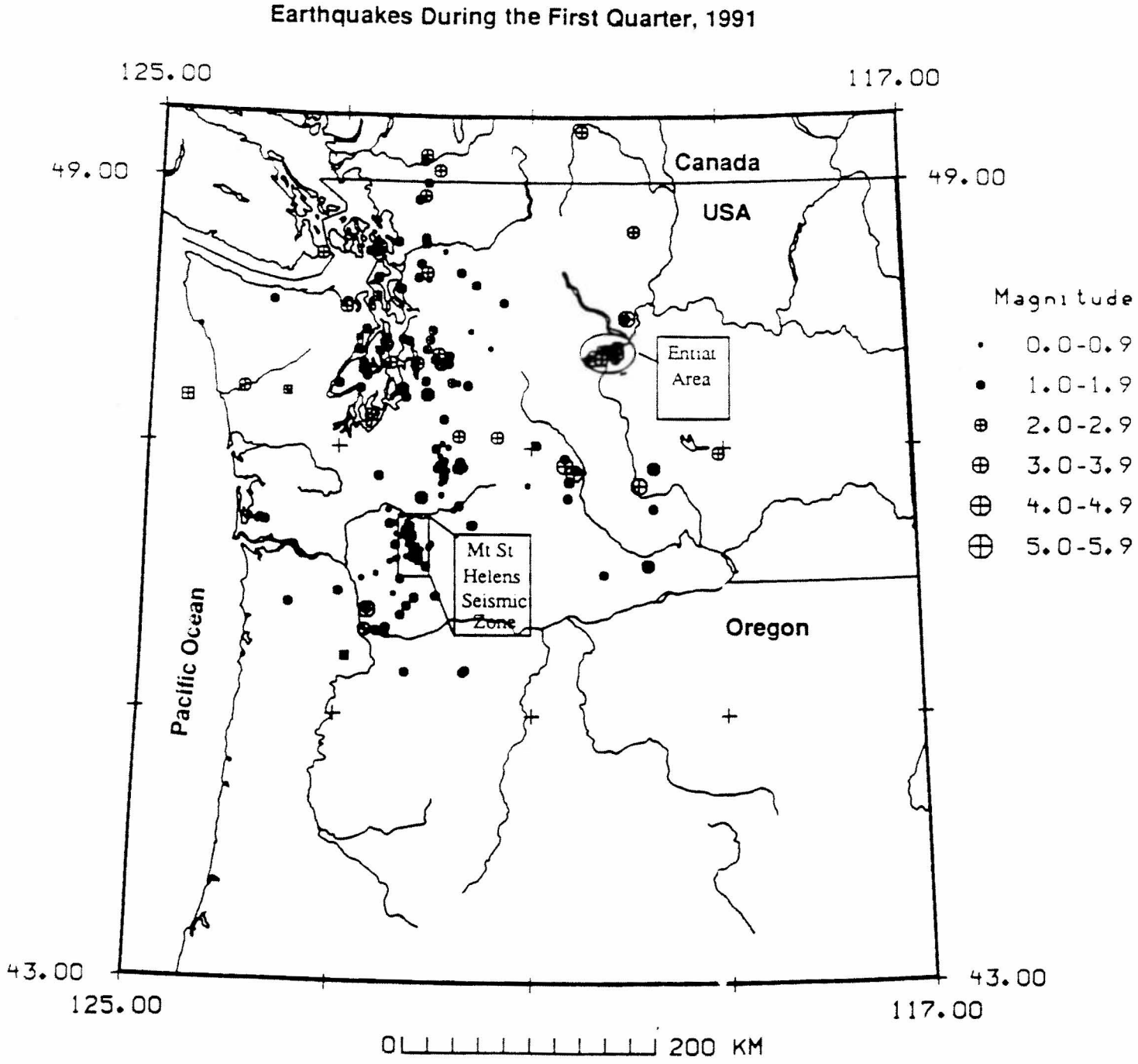

Figure 2. Earthquakes located in Washington and northern Oregon with magnitudes greater than 1.0. first quarter 1991. A square symbol indicates that an event located with a depth greater than or equal to 30 km. Octagonal symbols are used for events shallower than 30 km.

QUARTERLY NETWORK REPORT 91-B

on

Seismicity of Washington and Northern Oregon

April 1 through June 30, 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
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and

Westinghouse Hanford Company
Contract PMM-RJU-505

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INTRODUCTION

This is the second 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.

There were no new stations added to the network this quarter. As reported last quarter, station YEL was lost in a phreatic explosion. Another station, REM, was temporarily lost on February 5 during a similar event. The antenna was bent during the event, and was straightened on February 12, only to be damaged again on February 14 during another explosion event. It was repaired again on February 24. It is not clear whether station YEL can be fixed safely, given the uncertain nature of these explosions.

Washington Regional Seismograph Network

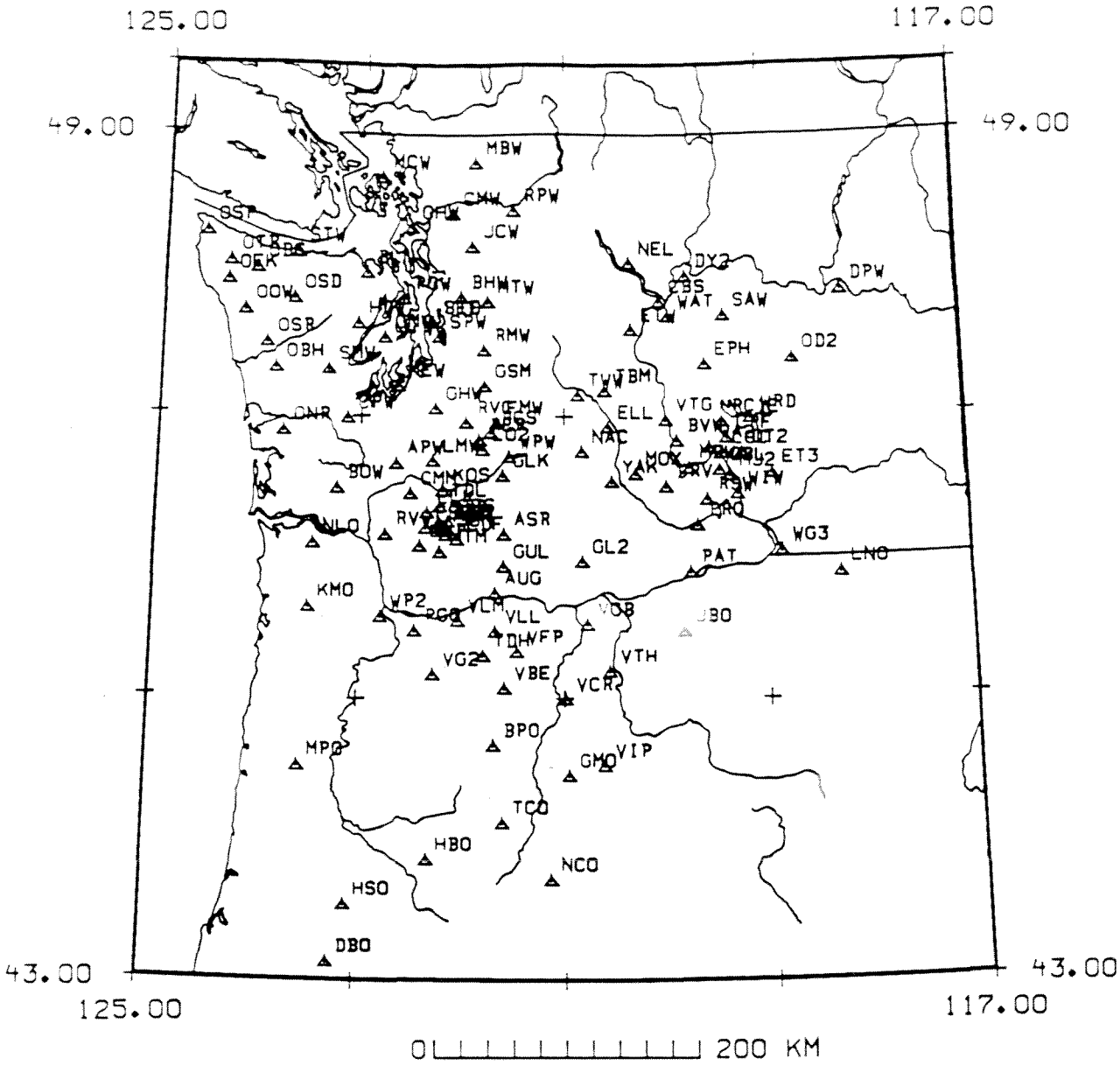

Figure 1. Stations operating during the second quarter, 1991.

TABLE 1
Station Outages 2nd quarter 1991

Station	Outage Dates	Comments
APW	March 21-End	Station removed during excavation work
APW	All period	Dead; reactivated nearby gravel pit
GLK	May 10-June 7	Dead
HDW	June 9-June 10	Dead; new VCO
JUN	June 18-June 24;Dead	
MPO	June 9-End	Dead, cut cable
MTM	June 19-June 26; Dead, lightning?	
OHW	April 27-May 1	Dead, batteries
OSR	May 24-early June	subcarrier dropped, fixed itself
REM	April 1-May 2	Intermittent, fixed at TDL
RER	May 3-End	Dead
RMW	April 24-June 11	Dead
TDH	All period	Dead
TWW	April 16-End	Very noisy (generator noise?)
VLL	April 18-May 7	Dead, batteries

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 (S) 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 Second Quarter 1991

STA	F	LAT	LONG	EL	NAME
APW	*	46 39 06.0	122 38 51.0	0.457	Alpha Peak
ASR	S	46 09 02.4	121 35 33.6	1.280	Mt. Adams - Stagman Ridge
AUG	S	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	S	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	S	46 06 58.2	122 02 51.0	0.780	Cedar Flats
CMM	S	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	S	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	S	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	S	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
FL2	S	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

EARTHQUAKE DATA

There were 707 events processed by the University of Washington digital recording seismic network between April 1 and June 30, 1991. Locations were determined for 467 of these in Washington and Northern Oregon; 363 were classified as earthquakes and 104 as known or suspected blasts. The remaining 240 processed events include teleseisms (130 events), regional events outside the U. W. network (27), 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 second quarter of 1991, 306 earthquakes were located between 43.5° 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 second quarter, there was only one earthquake reported felt in western Washington and Oregon. It occurred on May 15 (local time) at a distance of 14 km SW of the summit of Mt. Rainier, Washington. This event had a depth of 11.3 km and a M_c = 3.0. This event was felt at Mt. Rainier National Park headquarters. There were no reports of damage.

Eastern Washington and Oregon

This quarter, there were 57 earthquakes located in Eastern Washington. Of these earthquakes, only one was felt. This occurred on April 14 (local time) near the town of Brewster, Washington. (Brewster is located in Douglas County, approximately 35 km NE of Chelan). It was reported felt in both Brewster and

the town of Chelan. This event had a shallow depth (<5 km) and a M_c = 3.9. There were no reports of damage.

One other event did occur which had a M_c = 3.1, but was not reported felt. This occurred 17 km east of the summit of Glacier Peak, an isolated region west of Lake Chelan. This would explain why it was not reported felt. It was shallow (<5km). Activity in this area is not considered unusual.

Mount Rainier Area

There were 42 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 majority of the events in the summit region are ice quakes, as they are the result of glacial activity, and not tectonic in nature.

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

83 events were located at Mt. St. Helens this quarter. This quarter, there were no earthquakes which had magnitudes greater than 2. Of the total, 11 earthquakes were deeper than 4 km, and the rest were shallower. This represents a decline in the rate below this depth, where 33 occurred last quarter and 167 during the fourth quarter of 1990. 4 km separates events in the very shallow crust and volcanic edifice from those within the deeper magmatic system. This quarter saw no explosion events, which have been reported since 1989.

QUARTERLY NETWORK REPORT 91-C

on

Seismicity of Washington and Northern Oregon

July 1 through September 30, 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:

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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.

There were 5 new stations added to the network this quarter. All of them were added to the Oregon region of the network. Station SSO was installed on August 27, and is called Sweet Springs, Oregon. Station FBO (Farmers Butte, Oregon) was installed on August 28. Station WMO (Whaleback Mountain, Oregon) was installed on September 11. Station RNO (Roman Nose, Oregon) was installed on September 25. (The first data from this station became available on October 1, however, due to telemetry problems.) Lastly, station TKO (Trask Mountain, Oregon) was installed to replace an existing station GRO which was subject to continuous problems. This work was completed on August 15. These stations are supported by USGS contract 14-08-0001-A0623.

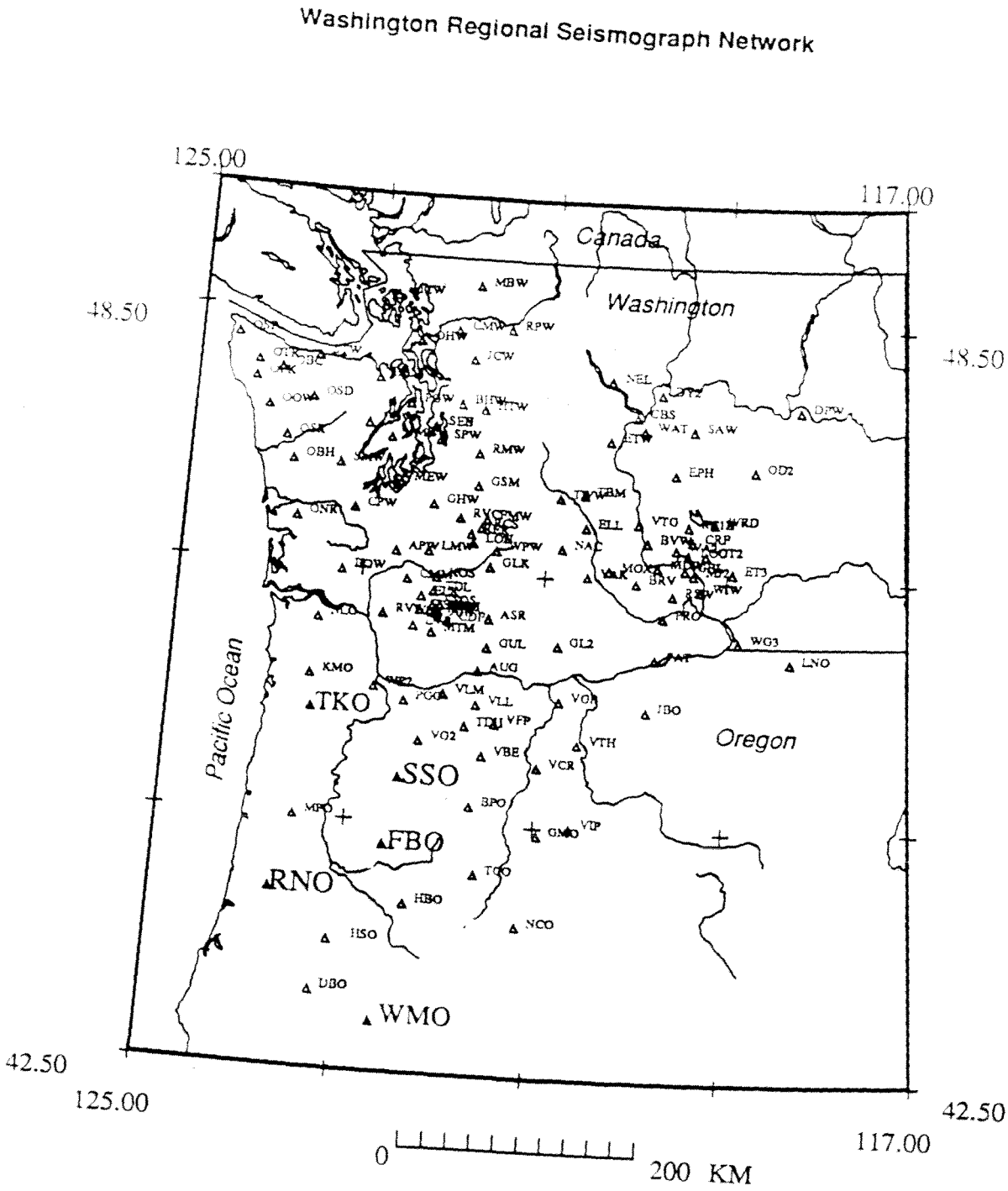

Figure 1: Stations operating at the end of the quarter, 1991

New stations are highlighted.

TABLE 1
Station Outages 3rd quarter 1991

Station	Outage Dates	Comments
CMW	July 1-July 10	Dead; replaced almost entire site
EPH	July 12-July 19	Transmitter problems
FBO	Beginning to Aug 28	New station
FL2	Sept 27-End	Dead
GHW	Aug 25-Sept 5	Dead
GRO	Whole Period	Replaced on Aug 15 by TKO
JUN	July 10-July 15	Off center frequency
KOS	Sept 11-Sept 14	Dead
LO2	July 30-Aug 3	Dead
LON	July 30-Aug 3	Dead
MCW	Sept 4-Sept 11	Dead
MEW	July 14-July 16	Dead
MJ2	Sept 6-Sept 12	Interference,dead
OBH	July 6-July 31	Off center frequency
OD2	July 12-July 15	Problem at relay
PGW	July 27-Aug 6,Aug 21-Sept 26	Dead
REM	Sept 13-End	Dead
RNO	Beginning to Sept 25	New station
RVC	July 6-July 22	Dead; no subcarrier
SSO	Beginning to Aug 27,Sept 8-Sept 9	New station, recv'r problem
TDH	July 1-July 3	(Was dead all second quarter);fixed and converted to solar
TKO	July 1-Aug 20	Replaced GRO
WMO	Beginning to Sept 11	New station
WRD	July 12-July 15	Problem at relay

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.

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TABLE

Stations Operating at ...rd 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.
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CBS	+	47 48 16.7	120 02 27.6	1.073	Chelan Butte, South
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COW	%	46 29 27.6	122 00 43.6	0.305	Cowlitz River
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ELK	%	46 18 20.0	122 20 27.0	1.270	Elk Rock
ELL	+	46 54 35.0	120 [illegible] 9	0.805	Ellensburg
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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

EARTHQUAKE DATA

There were 1010 events processed by the University of Washington digital recording seismic network between July 1 and September 30, 1991. Locations were determined for 699 of these in Washington and Northern Oregon: 549 of these were classified as earthquakes and 150 as known or suspected blasts. The remaining 311 processed events include teleseisms (111 events), regional events outside the U. W. network (101), 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 third quarter of 1991, 465 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 third quarter, there were five earthquakes reported felt in western Washington and Oregon. Two of them occurred 23 km West- Northwest of Portland, Oregon. The first occurred on July 22, and had a M_c = 3.5, and had a depth of approximately 20 km. This event was reported felt from the town of St. Helens to as far south as Salem. The second earthquake occurred only seven minutes later, and had a M_c = 2.2, with a similar depth. This was reported felt only in Portland. Neither of these caused any damage. These two events were part of a cluster of activity that started on July 17, with the number of events during the quarter finally totalling 26. The Portland basin is an area of known activity and has had many earthquakes in the past. This area is like other areas in Puget Sound where clusters of earthquakes with low magnitudes occur in the shallow crust and last for only a few weeks.

On July 25, a M_c = 3.2 earthquake occurred 12 km south of Bremerton, Wash. It was reported felt throughout Kitsap County, and had a depth of 25 km. There was no damage associated with this event. The last earthquake to be discussed in this section (See Mt. Rainier section for felt event information for an event in Mt. Rainier National Park) occurred on September 15 in the San Juan Islands. It was a M_c = 3.0 event and was felt on Orcas Island, Wash. This event was 34 km Northeast of Victoria, B.C., and was approximately 15 km deep. It caused no damage.

There was a cluster of earthquakes near Mt. Hood during the quarter, with all 12 of them occurring on August 18. All of them were quite small, with magnitudes less than 1.5. None of these were felt. This type of activity is consistent with patterns of activity at Mt. Hood, with shallow activity occurring for just one to a few days.

Eastern Washington and Oregon

During this quarter, there were 84 earthquakes located in Eastern Washington. None of these earthquakes were felt. The most significant activity was a cluster of earthquakes approximately 16 km East-Southeast of Ellensburg, on the east end of the Kittitas Valley. There were a total of 29 earthquakes during the quarter in this area, with the largest being a M_c = 3.4 on July 6. All of these events were shallow (less than 10 km). Elsewhere, activity was normal, with the usual seismicity (totalling ten events) near Entiat, Wa.

Mount Rainier Area

There were 83 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. Rainer. There was one earthquake reported felt by personnel working at the Ranger station within the park. It occurred on July 29, was a M_c = 2.3, and located approximately 8 km deep. This was located under the cone of Mt. Rainier, where activity of this type is not unusual.

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

102 events were located at Mt. St. Helens this quarter. The largest event had a M_c = 2.8 and occurred on September 10. Of the total, 27 earthquakes were deeper than 4 km, and the rest were shallower. The ratio between the 'deeper' and 'shallower' events continues to fluctuate, with the number of deeper events greater this quarter than last quarter. There seems to be no particular importance associated with this observation during the last few years.

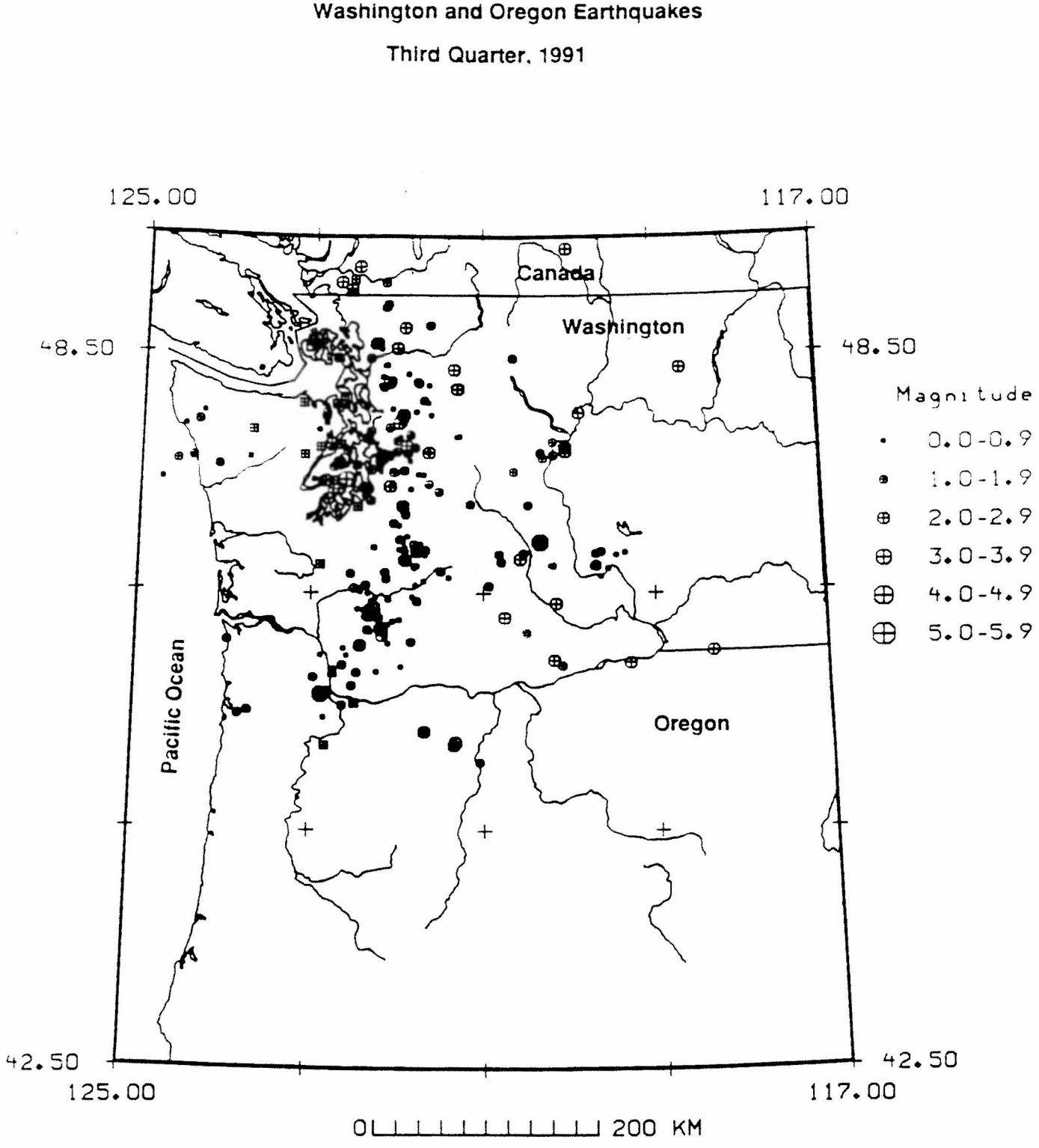

Figure 2: Earthquakes located in Washington and Northern Oregon with magnitudes greater than 1.0, third quarter, 199. A square symbol indicates that an event located with a depth greater than or equal to 30 km. Octagonal symbols are used for events shallower than 30 km.

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