QUARTERLY NETWORK REPORT 90-A

on

Seismicity of Washington and Northern Oregon

January 1 through March 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 first 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 station additions or deletions within the network this quarter. Station visits were primarily for routine maintenance, including replacement of batteries and minor repairs.

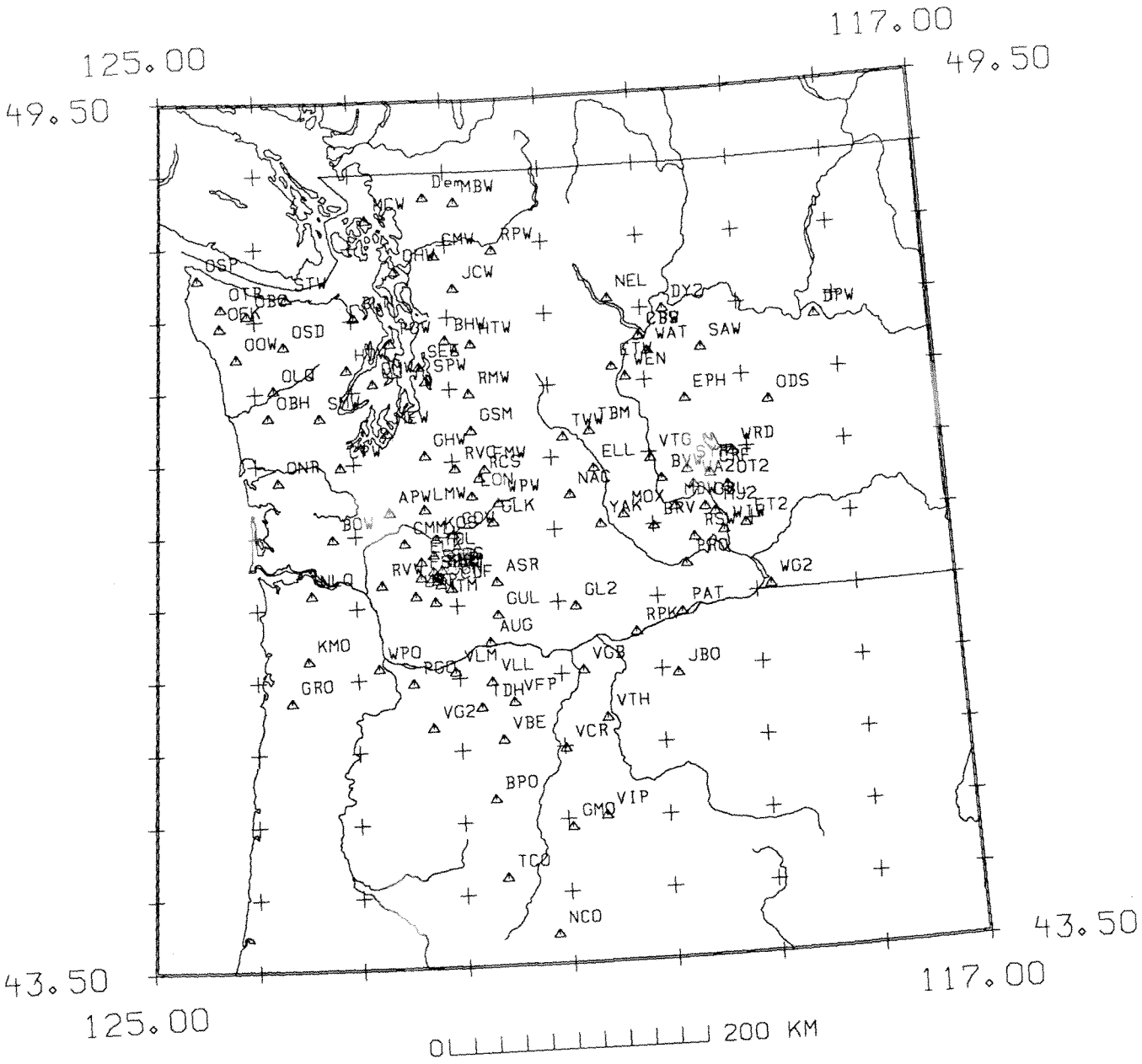

Figure 1. Seismograph stations operating during the first quarter 1990.

TABLE 1
Station Outages 1st quarter 1990

Station	Outage Dates	Comments
APW	February 5-February 8, January 10-January 12	Dead;antenna icing;power outage
BOW	February 5-February 8	Dead;antenna icing
BRV	January 28-February 2	Dead;storm
CDF	January 28-February 27	Buried and broken antenna
CPW	February 5-February 8	Dead;antenna icing
EDM	January 28-February 27	Buried and broken antenna
ELK	January 2-February 7	Dead;Problem with BPA equipment
FL2	February 8-February 11	Dead
FMW	February 9-February 12	Dead
GHW	February 9-February 12	Dead
GLK	January 27-February 12	Dead;whole line affected;storm
GSM	February 9-February 12	Dead
GUL	February 8-February 11	Dead
HSR	January 28-February 27	Buried and broken antenna
JUN	February 8-February 11	Dead
LMW	February 9-February 12	Dead
LO2	January 27-February 12	Dead;whole line affected;storm
LON	January 27-February 12	Dead;whole line affected;storm
MCW	February 1-February 23	Dead;power outage
MDW	January 28-February 2	Dead;storm
MOX	January 28-February 2	Dead;storm
MTM	January 28-February 27	Buried and broken antenna
NAC	January 28-February 2	Dead;storm
NLO	February 5-February 8, January 10-January 12	Dead;antenna icing;power outage
OBH	February 5-February 8	Dead;antenna icing
RER	January 30-February 12	Dead
RVC	January 30-February 12	Dead
RVW	February 5-February 8, January 10-January 12	Dead;antenna icing;power outage
SAW	January 28-February 2	Dead;storm
SHW	January 10-January 12	Dead;power outage
SMW	February 5-February 8	Dead;antenna icing
SOS	January 2-February 7	Dead;Problem with BPA equipment
STD	January 2-February 11	Dead
TCO	January 4-End	Intermitttent
WPW	January 27-February 12	Dead;whole line affected;storm
YAK	January 28-February 2	Dead;storm

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 2

Stations Operating at the End of the First 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.
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CRF	+	46 49 30.6	119 23 18.0	0.260	Corfu
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
ET2	+	46 27 53.4	119 03 32.4	0.250	Eltopia
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.
HDW	*	47 38 54.6	123 03 15.2	1.006	Hoodsport
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.
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
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
PGW	*	47 49 18.8	122 35 57.7	0.122	Port Gamble

continued

STA	F	LAT	LONG	EL	NAME
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, Or.
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
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
WG2	+	46 01 50.25	118 51 19.95	0.511	Wallula Gap
WIW	+	46 25 48.8	119 17 13.4	0.130	Wooded Island
WP2	+	45 33 57.20	122 47 06.90	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 810 events processed by the University of Washington digitally recording seismic network between January 1 and March 31, 1990. Locations were determined for 607 of these in Washington and Northern Oregon; 537 were classified as earthquakes and 70 as known or suspected blasts. The remaining 203 processed events include teleseisms (132 events), regional events outside the U. W. network (31), 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 4 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. 6 shows earthquakes located at Mount St. Helens ($M_c \geq 0$).

Western Washington and Oregon

560 earthquakes and blasts were located between 43.5 ° and 49.5 ° north latitude and between 121 ° and 125 ° west longitude during the first quarter of 1990. 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 this quarter, there were three earthquakes reported felt in Western Washington. The first event occurred approximately 8 km north of the town of Monroe on February 15. It registered a $M_c = 3.4$ and was approximately 16 km deep. It was reported felt in Monroe, Sultan, Granite Falls, Darrington, and Snohomish. Most reports included hearing rumbling and shaking sensations similar to a large dump truck unloading, and some reported hearing an explosion. Those that reported an explosion were within ten kilometers of the epicenter. The sound of an explosion is not uncommon with larger earthquakes, but for one this small, it's unusual.

The second felt event occurred on March 8, very near the town of Darrington. It had a M_c =3.6, and was one of 37 quakes in this area during the first quarter. As with most swarms of

activity that have shallow hypocentral locations, it is difficult to state exactly how many of these earthquakes were felt. Not all events are reported felt by local residents because they have become fairly common. As awareness to earthquake phenomenom increases, sensitivity to them also increases. The clustering of the activity in the Darrington area shows up well in Figure 2.

The third felt earthquake occurred near Federal Way, Wa. on March 17. This event had a M_c =3.0, and a depth of 7 km. Reports also came in from Kent, Midway, and Des Moines. There were no foreshocks or aftershocks associated with this event.

Otherwise, the only other interesting activity in Western Washington occurred 14 km southwest of Enumclaw, Wa, where there was a cluster of 8 events between January 1 and January 22. The largest was M_c =2.7 on January 2 and all were shallower than 11 km. None of these were reported felt.

Last quarter we reported that the activity at Mt. Rainier had been increasing during 1989 but appeared to be steady at that increased rate during the last quarter of 1989. The first quarter of 1990, however, showed a sharp decrease in the number of events in the cone of Mt. Rainier. There were only four located earthquakes under the summit this quarter, compared to 21 located last quarter.

Eastern Washington and Oregon

During the first quarter of 1990, 41 earthquakes were located in eastern Washington and Oregon. This is a continuation of the pattern of relatively low earthquake rates east of the Cascades that began during the last half of 1989. Prior to that time, many more earthquakes were recorded each quarter. The one area of concentrated activity is centered around the town of Entiat. This activity is normal, with frequent activity over the last twenty years. There were nine events in this area during this quarter, the same as last quarter.

There was just one event larger than M_c 3.0 in eastern Washington during the quarter. It occurred on March 1, and was located 31 km northeast of the town of Skykomish in the Wenatchee National Forest. It had a M_c 3.1, with a near-surface depth. It was not reported felt.

Mount St. Helens Area

Rates of activity in the Mt. St. Helens area continued to be steady during the first quarter. During last quarter, it was reported that activity had increased. This quarter saw a similar number or events. 251 events were located at Mt. St. Helens, whereas 293 earthquakes were located there last quarter. Like last quarter, the interesting aspect of the earthquakes at Mt. St. Helens is that most (163) of these occurred below a depth of 4 km. This depth separates events in the very shallow crust from those within the deeper magmatic system. This trend towards deeper activity was noted last quarter, and continued into this quarter. This emerging pattern may warrant monitoring in the future, as it reflects a departure in the pattern of seismicity when compared to activity in the early and mid 1980's. Prior to 1988, deeper activity tended to be compressed temporally and usually followed some type of eruption. It usually was isolated to a zone within the conduit system between 7 km and 12 km deep. The current activity occurs within a zone from about 4 km down to 8 km. Very few earthquakes below this depth have been recorded during the last three years.

In January, there was an ash emission from Mt. St. Helens. This was similar, though larger than an emission on December 7th that did not extend out of the crater, (reported last quarter). The January emission was more significant in that reports of ashfall came in from Yakima, Wa. The National Weather Service reported as much as 1/3" of ash had been reported in Yakima. The ash was emitted at 05:37PST on the 6th of January. The seismic signal associated with this event had a duration of about two minutes, then died down to low-level tremor with a few small, low frequency events mixed in the signal over the next two to three hours.

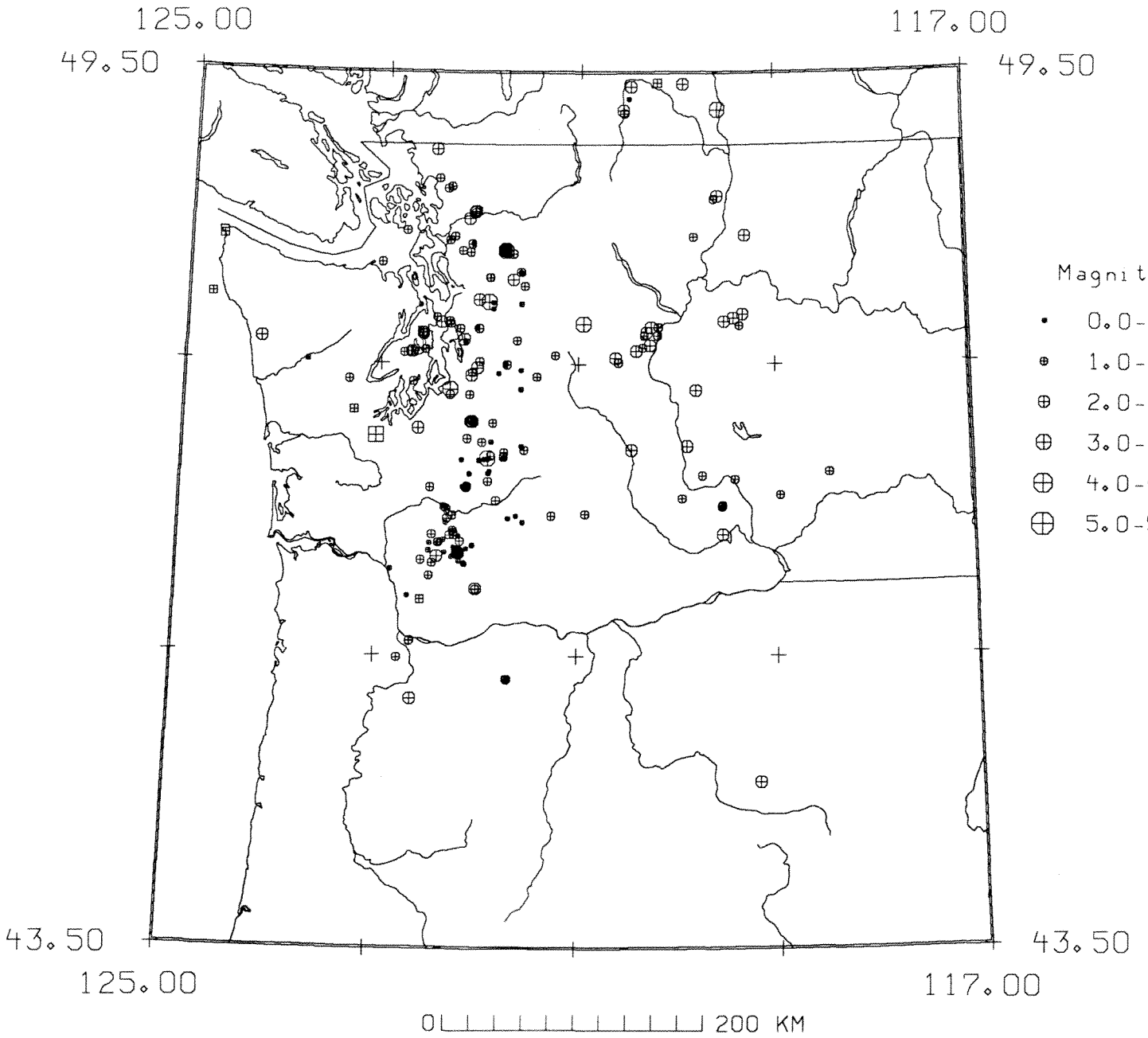

Figure 2. Earthquakes located in Washington and northern Oregon with magnitudes greater than 1.0, first quarter 1990. A square symbol indicates that an event located with a depth greater than or equal to 30 km. Octagonal symbols are used for events shallower than 30 km.

QUARTERLY NETWORK REPORT 90-B

on

Seismicity of Washington and Northern Oregon

April 1 through June 30, 1990

Geophysics Program

University of Washington

Seattle, Washington

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There were no station additions or deletions within the network this quarter. Station visits were primarily for routine maintenance, including replacement of batteries and minor repairs following a heavier than normal snow accumulation which was responsible for some damage at higher elevations.

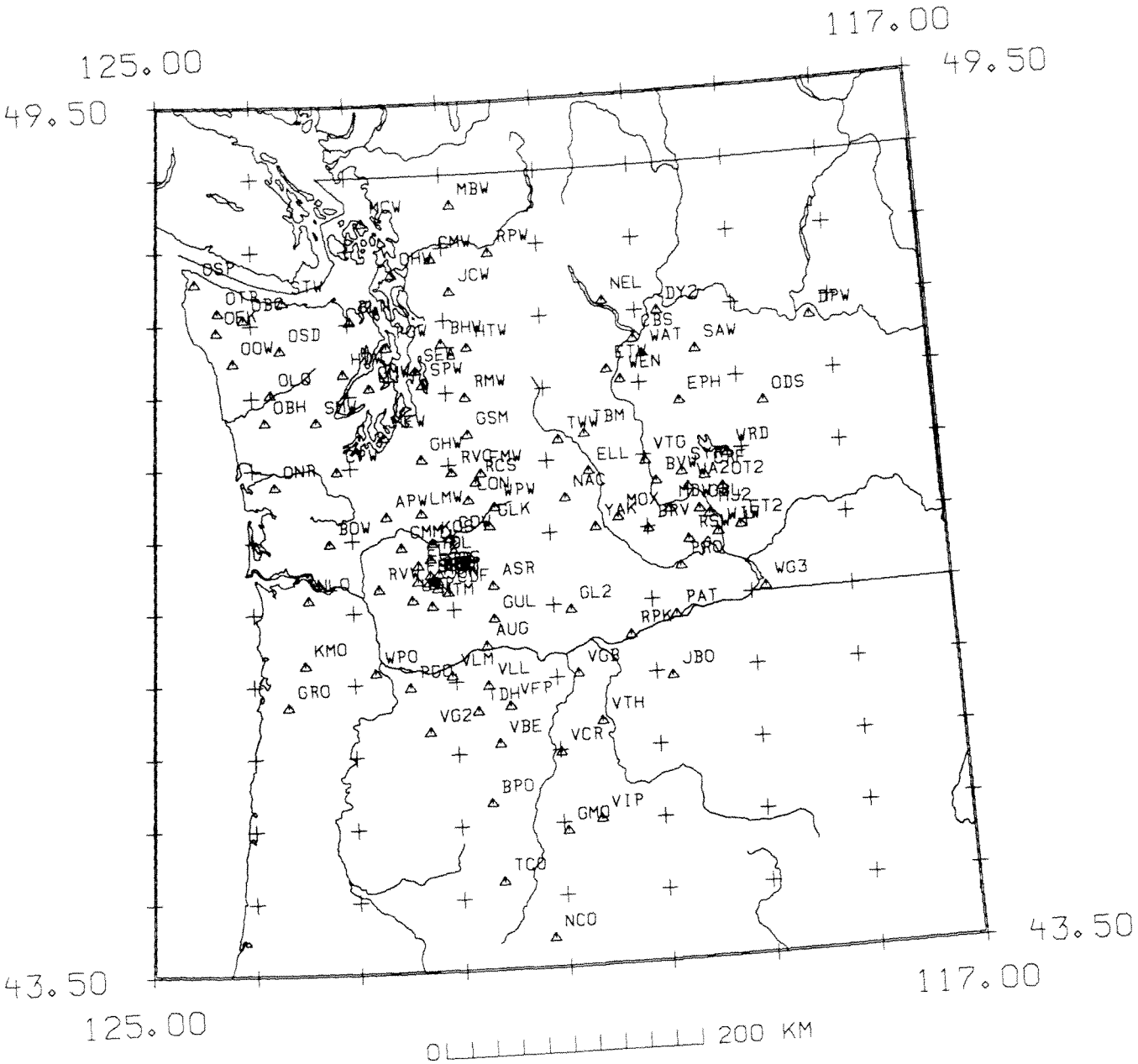

Figure 1. Seismograph stations operating during the second quarter 1990.

TABLE 1
Station Outages 2nd quarter 1990

Station	Outage Dates	Comments
ASR	June 16-June 18	Dead
BHW	April 27-May 1, May 20-June 5	Power outages
BVW	May 28-June 6	Dead; water in VCO
CDF	June 12-June 22	Dead; came back on by itself
CRF	April 1-May 8	Interfering with others on line
CRF	June 2-June 7	Storm?; dead
DPW	June 2-June 13	Intermittent
EPH	June 2-June 13	Intermittent
ET2	June 14-End	Dead
FL2	June 22-June 27	Water in VCO can
FMW	May 28-May 29	Dead
GHW	May 28-May 29	Dead
GLK	May 11-May 14	Dead
GRO	June 19-End	VCO off center freq, interfering with WP2
GSM	May 28-May 29	Dead
KOS	May 11-May 14	Dead
LMW	May 28-May 29	Dead
MDW	June 19-End	Bad battery cell
OBC	June 12-June 25	Intermittently dead
OFK	June 9-June 25	Dead
OSR	April 1-April 18, June 19-June 22	Cable chewed by rodents;Dead 2nd time
OTR	June 19-June 25	Dead
PRO	June 2-June 7	Storm?; dead
RMW	June 2-June 18	Lightning;dead
SHW	June 6-End	Dead;Snow damage during melt
SMW	May 22-End	Dead
SPW	April 7-April 11	Dead
VG2	April 1-May 3	Antenna misaligned by snow
VG2	June 22-End	Bad battery cell
WP2	June 20-End	Beating with station GRO interfering
WPW	May 11-May 14	Dead

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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
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FL2	$	46 11 47.0	122 21 01.0	1.378	Flat Top 2
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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.
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JBO	$	45 27 41.7	119 50 13.3	0.645	Jordan Butte, Oregon
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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.
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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
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MEW	*	47 12 07.0	122 38 45.0	0.097	McNeil Island
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MOX	+	46 34 38.0	120 17 35.0	0.540	Moxie City
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
PGW	*	47 49 18.8	122 35 57.7	0.122	Port Gamble

continued

STA	F	LAT	LONG	EL	NAME
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, Or.
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
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
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 digitally recording seismic network between April 1 and June 30, 1990. Locations were determined for 788 of these in Washington and Northern Oregon; 681 were classified as earthquakes and 107 as known or suspected blasts. The remaining 281 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. 6 shows earthquakes located at Mount St. Helens ($M_c \geq 0$).

Western Washington and Oregon

During the second quarter of 1990, 631 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 at depths greater than 30 km.

During this quarter, there were eleven earthquakes reported felt west of the Cascades, including Oregon and British Columbia. The majority (nine) of these occurred near the town of Deming, which was the location of the largest earthquake since the $M_c = 5.5$ 1981 Elk Lake Earthquake in southwest Washington. On Friday, April 13, a $M_c = 5.0$ earthquake occurred at 10:33 PDT (April 14, 05:33 UTC) and shook much of northwestern Washington and southern British Columbia. Deming is a small town about 20 km ENE of Bellingham, Wa. This swarm was rather intense, and April proved to be the most unnerving month for residents of the area. The activity followed a foreshock-aftershock pattern, with activity suddenly beginning on April 2, when a $M_c = 4.3$ earthquake occurred, waking many residents. This occurred at 4:13 AM PDT. Later

that same day, a M_c = 4.0 earthquake occurred at 7:18 PM PDT. It is quite unusual for two events of this magnitude to occur within the same day, and in fact hasn't occurred during the last decade in western Washington except in the area of Mt. St. Helens during it's eruptive activity in 1980. As noted, the activity peaked on April 13, and activity continued through the end of the quarter. A total of 109 earthquakes were located in a small zone about 3-5 km to the SSE of Deming during the quarter. Statistically, there were nine earthquakes with M_c =3.6 or greater. It should be noted that all of these earthquakes are believed to be within 5 km of the surface, and when one considers the reports of ground undulation and the number of reports where people heard the "crack" associated with these, they could be quite shallow. The regional network station coverage is rather sparse in this area, as it fringes on the northernmost edge of the network, but for the larger events we have incorporated data from the network run by the Pacific Geoscience Center in British Columbia. A special study is being conducted by Anthony Qamar, State Seismologist, and Jim Zollweg to relocate these events using additional data from portable seismographs. In addition to the nine earthquakes repored felt to the University of Washington, dozens more were felt in the epicentral area. As a result of the activity, the communities in and around Deming requested that seismologists from the Geophysics Program and the Geological Survey attend an open meeting for residents at Deming High School. On April 25, the meeting fielded questions from hundreds of local residents and was broadcast live on local radio. It was well attended by the local print and TV media, as well, and was a good forum that allowed residents to get first hand information about what to expect from a swarm such as this.

In addition to the concentrated activity near Deming, there were two felt events elsewhere. The first occurred in the Oregon coast range approximately 20 km east of Tillamook, Oregon on April 6. According to George Priest of the Oreon Dept. of Geology and Mineral Industries, it "knocked people off their feet" at 9:56 PDT (04:56 UTC). It had a depth of 44 km and appears to have a thrust mechanism. The other event actually occurred in the Province of British Columbia near Pender Island, just to the west of the San Juan Islands in northwest Washington. It was mildly felt in the Victoria, B.C. area, and one report came in from the Tillicum area of Saanich. This

event locates at a depth of 59 km.

Last quarter we reported that the activity at Mt. Rainier had been increasing during 1989 but appeared to have decreased during the first quarter of 1990. The second quarter of 1990, however, showed an increase in the number of events in the cone of Mt. Rainier, more closely resembling 1989 levels. There were 17 located earthquakes under the cone this quarter, compared with 4 located last quarter. This does not include 5 "ice quakes" that were located on the surface of the cone. Occasionally, these events are large enough and impulsive enough to be located, and are put into our catalog with the flag "L", which describes their low frequency character and is diagnostic in determining their source. In addition, there were 17 events located in the zone of activity to the west of the summit, which can be seen in Figure 2.

In addition to that, the only other cluster of activity in Figure 2 that stands out is the activity related to the Mt. St. Helens seismic zone, the northwest-southeast trending line in seismicity centered around Mt. St. Helens.

Eastern Washington and Oregon

During the second quarter of 1990, 50 earthquakes were located in eastern Washington and Oregon. This pattern of relatively low earthquake rates east of the Cascades began during the last half of 1989. Prior to that time, many more earthquakes were recorded each quarter. There were three areas of concentrated activity this quarter. One cluster of activity was centered around the town of Entiat. This activity is normal, with frequent activity over the last twenty years. There were 13 earthquakes in this area during this quarter, compared to nine last quarter. The largest event was a $M_c = 2.6$ on April 17. All these events were within 10 km of the surface.

On June 19, a $M_c = 3.2$ earthquake occurred just south of Moses Lake, 12 km west of Othello, and was one of 7 events to have occurred during the quarter in this cluster, as seen in Figure 2. The others are all less than magnitude 1.8, and are all within 5 km of the surface. The last noteworthy cluster occurred just south of the previous activity, and 30 km north of Richland. This is a tight cluster of just four earthquakes, occurring between May 19 and June 2. The average

coda magnitude is less than 1.7, but occurs in an area near Hanford which is monitored closely.

Mount St. Helens Area

During last quarter, it was reported that activity in the Mt. St. Helens area had increased. This quarter saw a similar number of events. 289 events were located at Mt. St. Helens, whereas 251 earthquakes were located there last quarter. Like last quarter, the interesting aspect of the earthquakes at Mt. St. Helens is that most (162) of these occurred below a depth of 4 km. This resembles last quarter's activity almost exactly. (There were 162 events below this depth last quarter). This depth separates events in the very shallow crust and volcanic edifice from those within the deeper magmatic system. There were only six earthquakes which had magnitudes greater that 2. There was no other noteworthy activity in this area.

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.

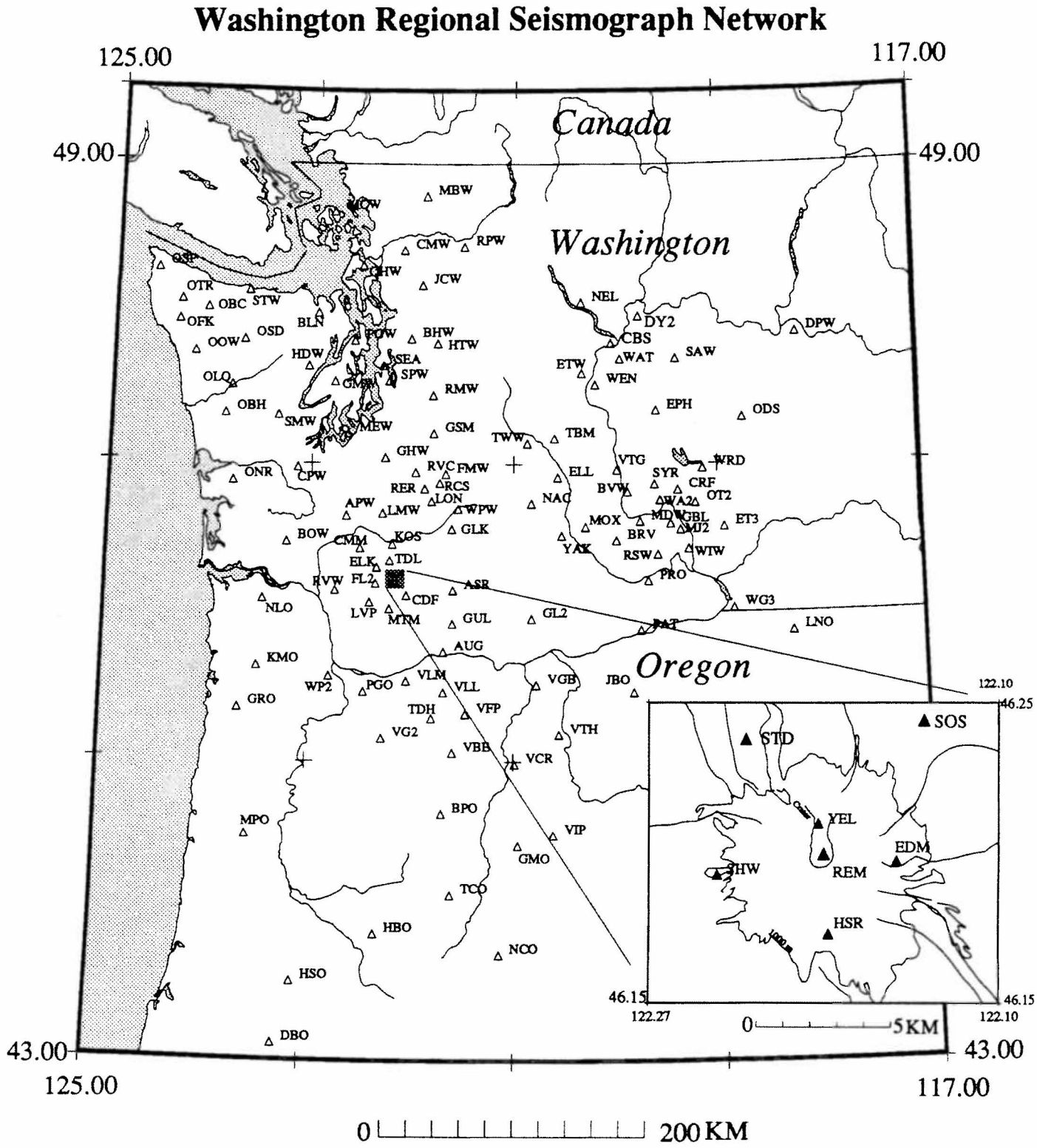

Figure 1. Seismograph stations operating during the fourth quarter 1990.

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
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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
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continued

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GUL	$	45 55 27.0	121 35 44.0	1.189	Guler Mt.
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HSO	$	43 31 33.0	123 05 24.0	1.020	Harness Mountain, Oregon
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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
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LNO	+	45 52 15.8	118 17 06.0	0.768	Lincton Mt., Oregon
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LON		46 45 00.0	121 48 36.0	0.853	Longmire (DWWSSN)
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MBW	*	48 47 02.4	121 53 58.8	1.676	Mt. Baker
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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	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, Or.
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
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
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.