QUARTERLY NETWORK REPORT 88-A

on

Seismicity of Washington and Northern Oregon

January 1 through March 31, 1988

Geophysics Program

University of Washington

Seattle, Washington

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INTRODUCTION

This is the first quarterly report of 1988 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.

In an attempt to better locate earthquakes occurring in a swarm near Hanford, Wa., the telemetry path of station HH2 was used to receive station LOC, located on the Hanford Reservation and operated by the Westinghouse Company. LOC is located within 5 km of the swarm activity. (See the Eastern Washington seismicity section for more details of this activity). LOC first began recording at the UW on January 28, and continued for the rest of the quarter.

A new vertical short period seismometer (LO2) was installed adjacent to station LON near Mt. Rainier. Station LON is a WWSSN long period seismometer, and the new short period seismometer

LO2 should aid in a study of earthquakes at Mt. Rainier. (See the Western Washington seismicity section for a more detailed discussion of this study).

Funding problems as reported last quarter continue into this quarter, and no certain termination date has been set for the 40 stations in Eastern Washington. Interim funding has been provided by DOE until a plan is developed for continuation of monitoring in eastern Washington. At this time it seems as if a scaled down version of the eastern Washington network will be supported in cooporation with Westinghouse.

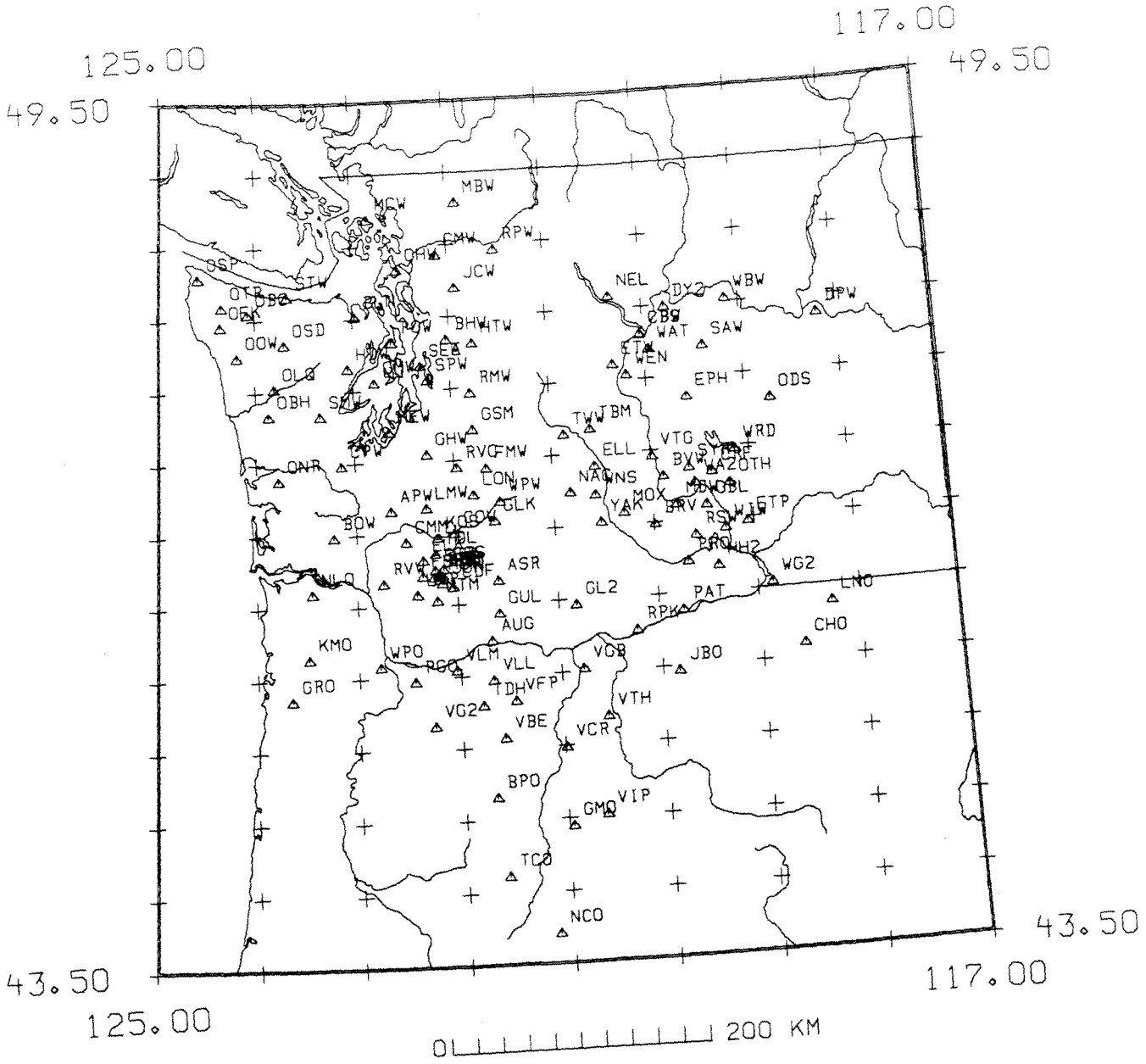

Figure 1. Seismograph stations operating during the 1st quarter 1988.

TABLE 1
Station Outages 1st quarter 1988

Station	Outage Dates	Comments
BHW	March 6-March 31	
GHW	March 9-March 31	
GMW	March 4-March 31	
PGW	March 4-March 21	
MEW	March 4-March 31	Intermittent, low gain
OHW	February 10-February 19	Cable chewed
NEL	January 1-January 11	
OBH	January 24-March 31	Loose connection
HH2	January 28-March 31	Temporarily replaced by LOC
LOC	January 1-January 28	Temporarily replaces HH2
ETW	Whole Period	
CHO	Whole Period	Intermittent; solar panel
WG2	Whole Period	Amplifier noise,intermittent
LVP	January 24-March 31	
NAC	January 1-January 11	
WNS	January 1-January 11	
REM	February 5-March 31	Problem with TDL txmitter
YEL	Whole Period	Problem with TDL txmitter
OSP	January 24-March 31	Off at OTR
STD	January 24-February 5	
HSR	Whole Period	Txmitter out
OBC	January 24-March 31	Off at OTR
SOS	January 11-February 22	Intermittent;solar panel at ELK
OSD	January 24-March 31	Dead
CMM	January 1-January 11	
OTR	February 13-March 31	Txmitter off
OLQ	March 4-March 31	Bad VCO
ELK	January 11-February 5	Solar panel problems
OFK	January 1-February 13	Intermittent
OOW	January 24-February 13	
PGO	January 24-February 22	Intermittent
GUL	March 4-March 31	Dead batteries
TDH	January 1-March 31	Intermittent
ASR	March 4-March 31	Batteries dead at GUL
GRO	Whole Period	Intermittent Rf problem
SEN	February 22-February 27	Power off
SEE	February 22-February 27	Power off
RPK	January 1-February 9	Output driver disconnected
TCO	Whole Period	Intermittent

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-A0266. Stations marked by ($) were supported by USGS contract 14-08-0001-21978. (+) indicates support under US Dept. of Energy contract DE-AM06-76RL02225. 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 1988

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
CHO	+	45 35 27.0	118 34 45.0	1.076	Cabbage Hill, Oregon
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
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
ETP	+	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
FOX	+	48 19 50.0	119 42 29.0	0.896	Fox Mountain
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
HH2	+	46 10 18.0	119 23 01.0	0.490	Horse Heaven Hills (moved HHW)
HSR	$	46 10 22.2	122 10 58.2	1.774	South Ridge, Mt. St. Helens
HTW	*	47 48 12.5	121 46 08.6	0.829	Haystack Lookout
JBO	$	45 27 41.7	119 50 13.3	0.645	Jordan Butte, Oregon
JCW	*	48 11 36.6	121 55 46.2	0.616	Jim Creek
JUN	$	46 08 48.0	122 09 10.8	1.049	June Lake
KMO	$	45 38 07.8	123 29 22.2	0.975	Kings Mt., Oregon
KOS	$	46 27 40.8	122 11 25.8	0.828	Kosmos
LMW	*	46 40 04.8	122 17 28.8	1.195	Ladd Mt.
LNO	+	45 52 15.8	118 17 06.0	0.768	Lincton Mt., Oregon
LOC		46 43 04.8	119 25 54.6	0.201	Rohay Station
LO2		46 45 00.0	121 48 36.0	0.853	Longmire
LON		46 45 00.0	121 48 36.0	0.853	Longmire (WWSSN and 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
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
ODS	+	47 18 24.0	118 44 42.0	0.523	Odessa
OFK	$	47 57 00.0	124 21 28.1	0.134	Olympics - Forks
OHW	*	48 19 24.0	122 31 54.6	0.054	Oak Harbor
OLQ	$	47 30 58.1	123 48 31.5	0.121	Olympics - Lake Quinault
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
OTH	+	46 44 20.4	119 12 59.4	0.260	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
PRO	+	46 12 45.6	119 41 09.0	0.552	Prosser

continued

STA	F	LAT	LONG	EL	NAME
REM		46 11 57.0	122 11 03.0	2.102	Rembrandt (Dome station)
RMW	*	47 27 34.9	121 48 19.2	1.024	Rattlesnake Mt. (West)
RPK	+	45 45 42.0	120 13 50.0	0.330	Roosevelt Peak
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.
SND	$	46 12 45.0	122 11 09.0	1.800	St. Helens Microphone, unrectif
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
SYR	+	46 51 46.8	119 37 04.2	0.267	Smyrna
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
WBW	+	48 01 04.2	119 08 13.8	0.825	Wilson Butte
WEN	+	47 31 46.2	120 11 39.0	1.061	Wenatchee
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
WNS	+	46 42 37.0	120 34 30.0	1.000	Wenas
WPO	$	45 34 24.0	122 47 22.4	0.334	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 513 events processed by the University of Washington digitally recording seismic network between January 1 and March 31, 1988. Locations were determined for 367 of these in Washington and Northern Oregon; 314 were classified as earthquakes and 53 as known or suspected blasts. The remaining 146 processed events include teleseisms (97 events), regional events outside the U. W. network (22), 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 located. In addition, during eruptive phases of Mount St. Helens, we may locate only a representative sample of the earthquakes that occur under the volcano.

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 1.0 ($M_c \geq 1.$) Fig. 3 shows blasts and probable blasts ($M_c \geq 0.$) Fig. 4 shows all earthquakes located in western Washington ($M_c \geq 0.$) Fig. 5 shows all earthquakes located in eastern Washington ($M_c \geq 0.$) Fig. 6 shows earthquakes located at Mount St. Helens ($M_c \geq 0$).

Western Washington and Oregon

172 earthquakes were located between 43.5° and 49.5° north latitude and between 121° and 125° west longitude during the first quarter of 1988. 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. The deepest earthquake located during the quarter had a $M_c = 3.9$, and occurred at a depth of 64.7 km near Tacoma, Wa. on March 11. This was the largest event during the quarter as well and was felt from Federal Way to Southeast Olympia. This was one of 4 earthquakes felt during the first quarter in western Washington. The first occurred on January 8,and was $M_c = 2.7$ at a shallow depth. It was felt in Enumclaw, and located under Spar Pole Hill (10 km east of our GHW site). On January 26, an earthquake was felt in North Bend, and was $M_c = 2.9$ at a depth of 19.7 km. On March 12, another earthquake was felt near Darrington, and was $M_c = 2.5.$, with a depth of less than 6km.

This past quarter, seismicity at Mt. Rainier was reexamined by Dr. Anthony Qamar. About 90 earthquakes have been located there since 1980. The earthquakes fall into two general categories: 1)impulsive, usually high frequency (f > 5hz) events and, 2) emergent, usually low frequency (3 to 5 hz) events. The high frequency events are probably tectonic earthquakes but their average depth is usually only a few kilometers below the summit of Rainier. The two events reported this quarter are of the impulsive type. There has been controversy about whether the source of the low frequency events was volcanic or glacial. Weaver and Malone *(Journal of Glacialogy, 123,171-184,1979)*, give evidence that low frequency events appear to be caused by the motion of glaciers on the mountain. The locations of both the impulsive and emergent earthquakes at Mt. Rainier are very near the summit, usually within the 7000 foot contour. Although low frequency events occur more often than high frequency ones, they are usually very small and cannot be located with our existing seismic network. Therefore, since 1980, only 22% of the event locations we have reported at Mt. Rainier are of the emergent type.

Eastern Washington and Oregon

During the first quarter of 1988, 147 earthquakes were located in eastern Washington. The Entiat area south of Lake Chelan was again active and one event was felt. On February 6, a M_c = 3.0 earthquake occurred, and was felt in the Waterville area south of Lake Chelan. Earthquakes in this area are common, with about 15 to 20 small events occurring nearby each quarter.

The swarm that began on October 2 near the town of Corfu, Wash. (50 km north of Richland) continued into the first quarter of 1988. In addition to the 52 events located last quarter, 39 were recorded this quarter. The largest event had a magnitude M_c = 2.9 on February 2. Most had magnitudes greater than 1.0, in contrast to last quarter when most had magnitudes less than 1.0.

A cluster of 6 events between January 8 and January 10 occurred in the Horse Heaven Hills area south of Prosser, Wash. They were generally around 9 km depth, with one locating at 13.3km. They had coda magnitudes between 1.3 and 1.5. Elsewhere in eastern Washington, earthquakes generally occurred as isolated events rather than in clusters.

Mount St. Helens Area

Seismic activity at Mt. St. Helens has been closely monitored since 1980. In the quarterly Network Reports, we regularly report earthquakes located on or near the mountain. However, we also keep much more detailed records of seismic activity at Mt. St. Helens. In particular, we maintain special tallies (or "counts") of earthquakes at Mt. St. Helens by scanning continuously recorded helicorder records from station SHW on the west flank of the mountain.

Events are "counted" and classified by type if their zero-to-peak amplitude exceeds 2.5mm on the SHW helicorder record (operated at a helicorder attenuator setting of -18db). With the calibrated seismometer at SHW, installed in October 1987, the helicorder record has a displacement-magnification of 2,900 at 1hz (19,900 at 5hz and a maximum of 29,000 at 10hz). Hence, a 5hz event would be "counted" if the true ground motion at SHW had an amplitude of 2.5mm/19,900 or 1.3×10^{-4} mm. All "counted" events are classified as type h,l,e,a,s, or t. These codes generally indicate that the event is a high frequency, low frequency, or medium frequency earthquake, an avalanche, a steam-emmission, or tremor, respectively. A more detailed description of these classification codes can be found in Malone *(Soc. Itiliana di Fisica, V85, 435-455, 1989).* Although not reported in the Quarterly Bulletins, "count" data along with occassional field observations and interpretations are reported in the monthly UW and USGS "Mt. St. Helens Seismic Report", as well as in the Cascade Volcano Observatorys' Monthly Report. Information about the "count" logs can also be obtained by special request from the University of Washington Geophysics Program.

The quiet that remained at the end of the last quarter in the Mt. St. Helens area continued into the first quarter of 1988. 40 earthquakes were located at Mt. St. Helens during the first quarter. 28 deep earthquakes during the first quarter. (Deep activity is considered to be earthquakes deeper than 3 km). In contrast to last quarter where most were greater that magnitude 1.0, this quarter saw only one event of $M_c = 1.0$, and most smaller than $M_c = 0.5$