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QUARTERLY TECHNICAL REPORT NO. 3

FOR

HANFORD AND CENTRAL SEISMIC NETWORKS

January 1, 1976 through March 31, 1976

by

Geophysics Program
University of Washington
Seattle, Washington 98195

May 1, 1976

Operational Status

During the first quarter of 1976 there were no major problems encountered.

Data

Fig. 1 shows the present location of all stations in the Hanford and Central Net. Fig. 2 reflects the regional seismicity during the first quarter of 1976. An asterisk indicates a depth greater than 10 km. During the first three months of 1976 there were 48 events located by the network. These events are listed with the station arrivals and also listed with a single line for each event. As seen in Fig. 2, there are four areas of swarm activity: The Wooded Island area is still active. The area just south of Othello remains active. The swarm activity at Midway has picked up and migrated to the east slightly. A new swarm area is noted just north of Grand Coulee Dam. This Coulee Dam activity may be from explosions and we are investigating that possibility. Three of them are confirmed explosions.

Publication

There were no Geophysics Program publications during the first quarter of 1976.

Progress of Research Tasks

We are waiting on the U.S. Geological Survey's report pertaining to the seismicity of the Hanford area before we can evaluate previously recorded data since 1970.

Efforts on relating surface geology to patterns of seismic activity are continuing.

Since the submittal of the Annual Progress Report (March 30, 1976), there has been no additional field work in eastern Washington.

An update of the preliminary ARPIC epicenter location program has just been completed. This is a refinement of the present program to facilitate a more convenient system of processing the preliminary data for the modified HYPO 71-1 location program, as outlined in the 1976 Annual Progress Report.

Organizational Plan

Included in this report is an organizational chart (Fig. 3) reflecting responsibility for research tasks and the people involved. This chart is related to the proposed research submitted to your office on March 26, 1976.

GEOPHYSICS PROGRAM
UNIVERSITY OF WASHINGTON

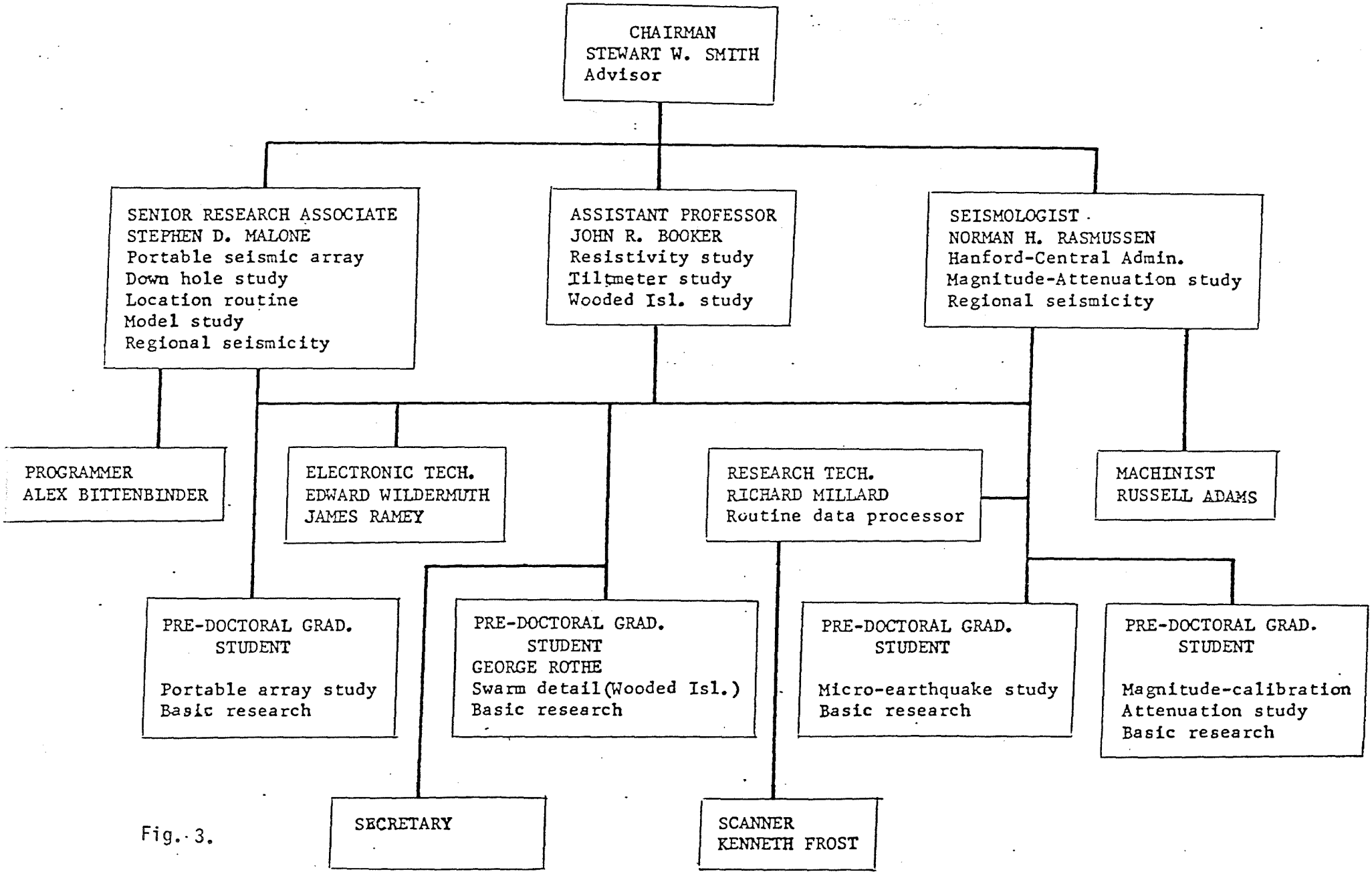


Fig. 3.

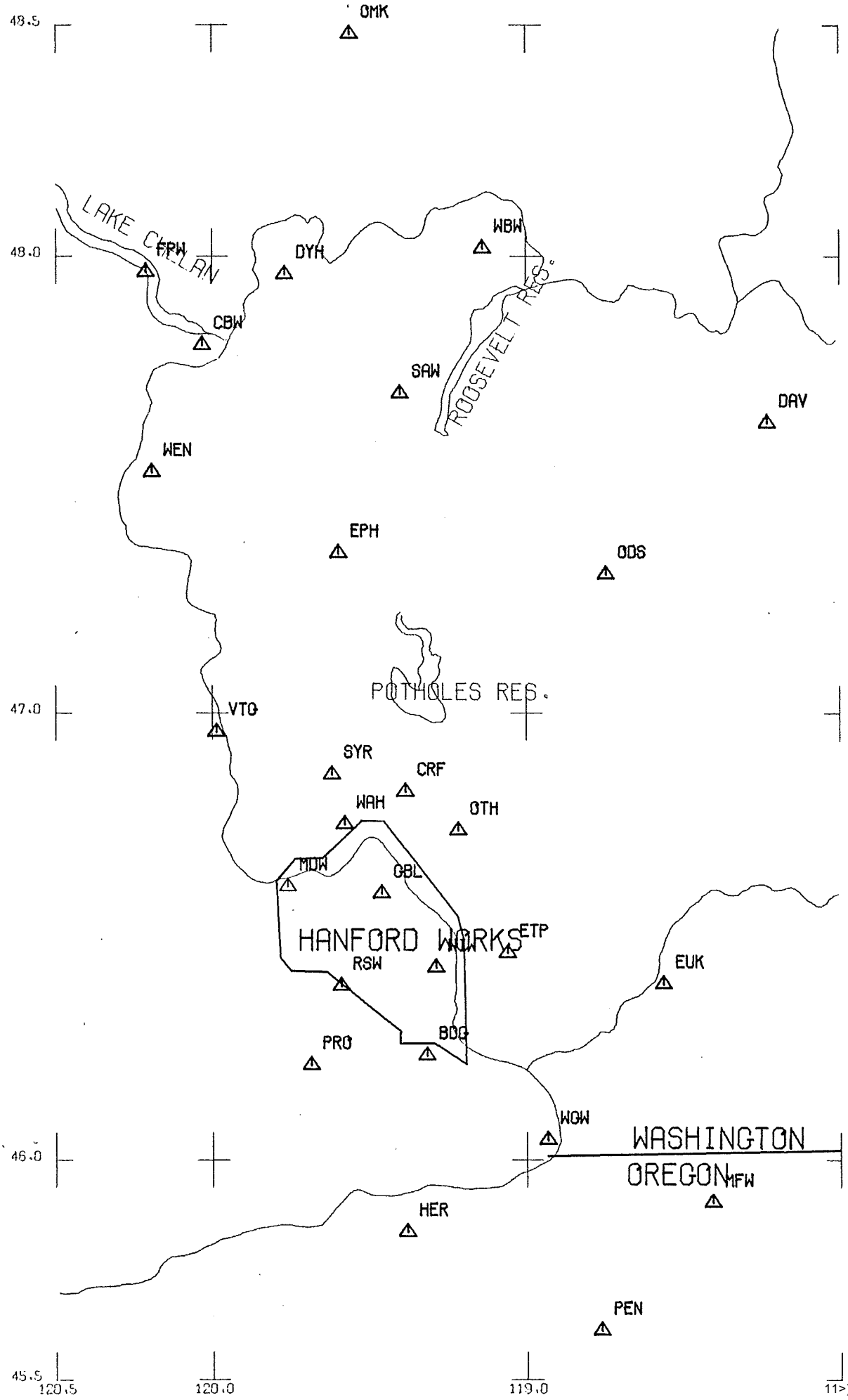
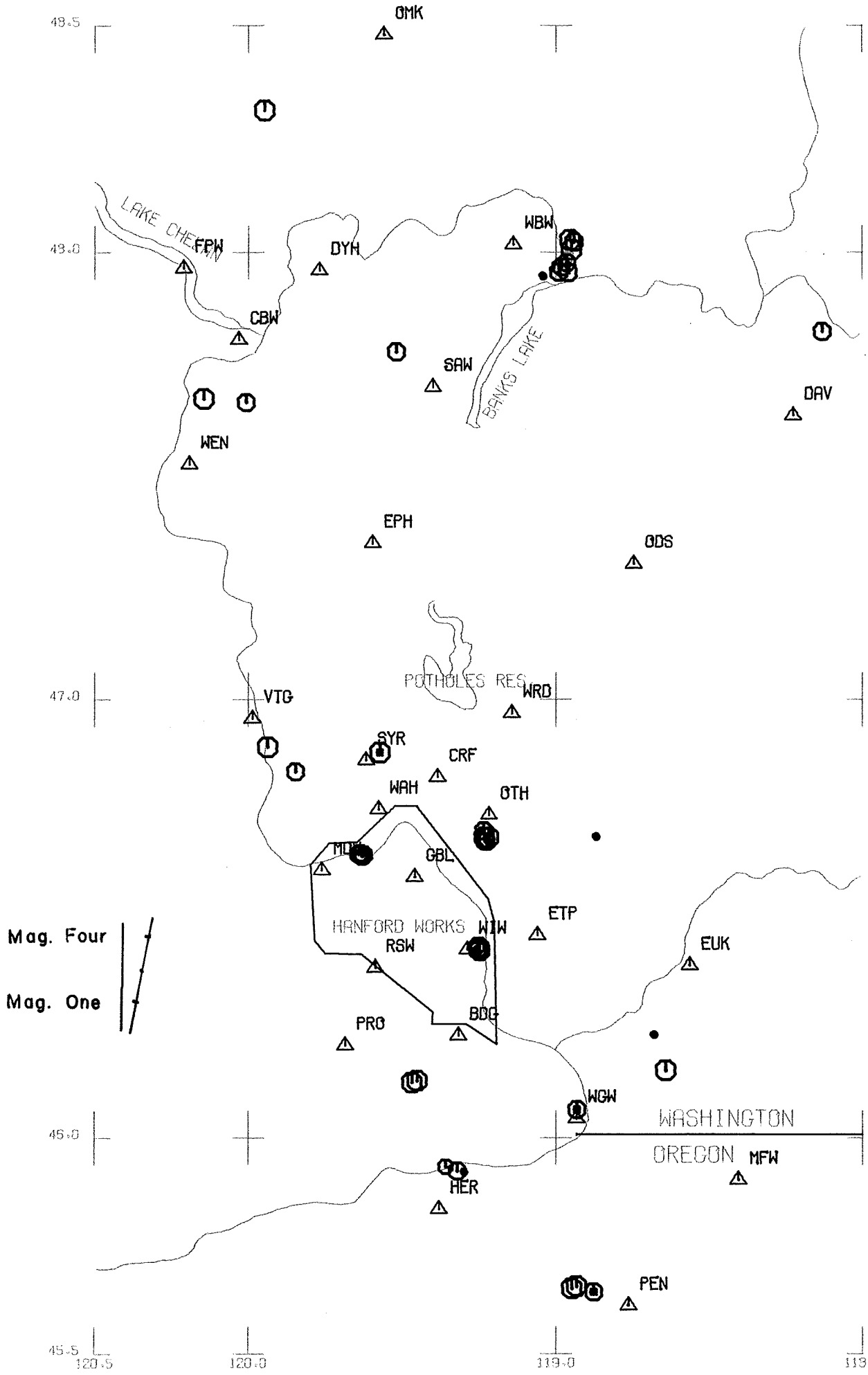


Fig. 1. EASTERN WASHINGTON SEISMIC STATIONS



EASTERN WASHINGTON JAN - MARCH 1976 Figure 2

The following is an explanation of the headings from the computer printout listing the located earthquakes (without station arrivals) and the located earthquakes (with station arrivals).

EXPLANATION OF COMPUTER OUTPUT
WITHOUT STATION ARRIVALS

Heading	Example	Explanation
YRDAY	76117	April 26, 1976 is date of earthquake
TIME	5 49	05 hr., 49 min. origin time
SEC	4.76	04.76 seconds origin time
LAT N	46-41.23	46^{o} - 41.23 minutes north latitude epicenter location
LONG W	119-13.38	119^{o} 13.38 minutes west longitude epicenter location
Z	6.83	6.83 kilometers is the depth of the earthquake
MAG	2.84	FMAG, magnitude of earthquake
#PZ	6	number of phases picked for that event
AZ GAP	126	largest gap of no data from stations; listed in degrees
ΔNR ST	22.6	distance in kilometers from epicenter to nearest station recording event
RMS	.14	root mean square
ΔER	2.2	possible error in epicenter location in kilometers
ZER	.8	possible error in depth of hypocenter location in kilometers
QAL	B1	quality of hypocenter location A1 = excellent B1 = good C1 = fair D1 = poor

EXPLANATION OF COMPUTER OUTPUT WITH STATION ARRIVALS

Hypocenter Output.

Heading	Example	Explanation
DATE	700630	Date of earthquake: Year, month, and day. In this case, it is June 30, 1970.
ORIGIN	1659 24.05	Origin time: hour, minute, and second (Greenwich civil time). In this case, it is 16 hr, 59 mn, and 24.05 sec.
LAT	37-48.64	Latitude of epicenter in degrees and minutes: 37° 48.64'.
LONG	121-57.59	Longitude of epicenter in degrees and minutes: 121° 57.59'
DEPTH	3.62	Focal depth in km: 3.62 km. A '*' may follow the DEPTH to indicate a fixed focal depth solution.
MAG	1.35	Magnitude of the earthquake. User specifies its choice from XMAG and/or FMAG.
NO	15	Number of station readings used in locating the earthquake. P and S arrivals for the same station are regarded as 2 readings. If NO = 3, a fixed depth solution is given. If NO<3, no solution is given.
DM	2	Epicentral distance in km to the nearest station.
GAP	110	Largest azimuthal separation in degrees between stations.
M	1	Crustal model number. M is used for the Variable First-Layer Model only.
RMS	0.09	Root mean square error of time residuals in sec. $RMS = \sqrt{\Sigma R_i^2/NO}$, where R_i is the time residual for the i^{th} station.
ERH	0.4	Standard error of the epicenter in km.* $ERH = \sqrt{SDX^2 + SDY^2}$, where SDX and SDY are the standard errors in latitude and longitude, respectively, of the epicenter. If ERH = blank, this means that ERH cannot be computed because of insufficient data.

ERZ 1.2

Standard error of the focal depth in km.* If ERZ is blank, this means that ERZ cannot be computed either because focal depth is fixed in the solution or because of insufficient data.

Q B

Solution quality of the hypocenter. This measure is intended to indicate the general reliability of the solution:

Q	Epicenter	Focal Depth
A	Excellent	good
B	good	fair
C	fair	poor
D	poor	poor

Q is taken as the average of QS and QD (defined below). For example, an A and a C yield a B, and two B's yield a B. When QS and QD are only one level apart, the lower one is used, i.e., an A and a B yield a B.

SQD A|B

QS and QD rating, In this case, QS = A, and QD = B. QS is rated by the statistical measure of the solution as follows:

QS	RMS (sec)	ERH (km)	ERZ (km)
A	< 0.15	≤ 1.0	≤ 2.0
B	< 0.30	≤ 2.5	≤ 5.0
C	< 0.50	≤ 5.0	
D	Others		

QD is rated according to the station distribution as follows:

QD	NO	GAP	DMIN
A	≥ 6	≤ 90°	≤ DEPTH or 5 km
B	≥ 6	≤ 135°	≤ 2x DEPTH or 10 km
C	≥ 6	≤ 180°	≤ 50 km
D	Others		

Heading	Example	Explanation
ADJ	0.0	Last adjustment of hypocenter in km. Normally this is 0 or less than 0.05.
IN	0	Instruction code (KNST and INST in input)
NR	17	Number of station readings available. This includes readings which are not used in determining hypocenter.

* Statistical interpretation of standard errors involves assumptions which may not be met in earthquake locations. Therefore the standard errors may not represent actual error limits.

AVR	0.00	Average of time residuals in sec. AVR $\equiv \Sigma_i R_i/NO.$ Normally this is 0.
AAR	0.07	Average of the absolute time residuals in sec. AAR $\equiv \Sigma_i \lvert R_i \rvert /NO.$
NM	5	Number of station readings available for computing maximum amplitude magnitude (XMAG).
AVXM	1.4	Average of XMAG of available stations.
SDXM	0.1	Standard deviation of XMAG of available stations.
NF	3	Number of station readings available for computing F-P magnitude (FMAG).
AVFM	1.3	Average of FMAG of available stations.
SDFM	0.2	Standard deviation of FMAG of available stations.
I	4	Number of iterations to reach the final hypocenter.

Station Output.

After each hypocenter output of 2 lines, station output follows for each station.

Heading	Example	Explanation
STN	BOL	Station name.
DIST	1.3	Epicentral distance in km.
AZM	202	Azimuthal angle between epicenter to station measured from north in degrees.
AIN	94	Angle of incidence measured with respect to downward vertical.
PRMK	IPUO	This is PRMK from input data.
HRMN	1659	Hour and minute of arrival time from input data.
P-SEC	25.30	The second's portion of P-arrival time from input data.
TPOBS	1.25	Observed P-travel time in sec. TPOBS $\equiv$ T + DT - ORG where T is the P-arrival time, ORG is the origin time, and DT is the time correction from input data.

TPCAL	1.09	Calculated travel time in sec.
DLY/H1	0.05 or 3.12	If the Station Delay Model is used, then DLY means the station delay in sec from the input station list. If the Variable First-Layer Model is used, then H1 means the thickness of the first-layer in km at this station.
P-RES	0.16	Residual of P-arrival in sec. If the Station Delay Model is used, then P-RES ≡ TPOBS - (TPCAL + DLY). If '**' follows P-RES, it means that in the Jeffreys' weighting, this P-arrival is not reliable. If the Variable First-Layer Model is used, then P-RES ≡ TPOBS - TPCAL.
P-WT	1.06	Weight used in hypocenter solution for P-arrival. This weight is a combination of quality weight specified in the data and other selected weightings. WT's are always normalized so that the sum is equal to NO. Normalization is necessary so as to avoid distortion in computing standard errors.
AMX	15.0	Maximum amplitude in mm from input data.
PRX	0.10	Period of maximum amplitude in sec. from input data. If PRX is not given on the phase card, then PRR from the corresponding station card is used in the computation of XMAG, but is not printed here.
CALX	2.20	Calibration in mm used in computing XMAG. If CALX is blank in the phase card, then CALR from the corresponding station card is used and is printed here as CALX.
K	5	System number for the station from input data.
XMAG	1.60	Maximum amplitude magnitude computed from AMX, PRX, CALX and K. A * follows XMAG if XMAG - AVXM $\geq$ 0.5.
RMK	Q05	Remark from input data.
FMP	10.0	F-P in sec from input data.
FMAG	1.02	F-P magnitude computed from F-P and DIST. A * follows FMAG if FMAG - AVFM $\geq$ 0.5.
SRMK	$ES_{\Delta}2$	This is SRMK from input data.
S-SEC	26.50	The second's portion of S-arrival time from input data.

TSOBS	2.45	Observed S-travel time in sec. TSOBS ≡ T + DT - ORG, where T is the S-arrival time, ORG is the origin time, and DT is the time correction from input data.
S-RES	-0.22	Residual of S-arrival in sec. If the Station Delay Model is used, then S-RES ≡ TSOBS - POS* (TPCAL + DLY). If the Variable First-Layer Model is used, then S-RES ≡ TSOBS - POS*TPCAL.
S-WT	0.5	Weight used in hypocenter solution for S-arrival. See explanation of P-WT for additional information.
DT	blank	Station time correction in sec. from input data. DT is used to correct all stations to the same time base.

YRDAY	TIME	SEC	LAT N	LONG W	Z	MAG	# PZ	AZ GAP	ΔNR ST	RMS	ΔER	ZER	QAL	DATE
76001	549	4.76	46-41.23	119-13.10	2.26	2.62	14	126	19.9	.14	.5	.8	B1	Jan. 1, 1976
76003	1348	57.92	46-42.12	119-14.00	2.90	1.92	6	193	17.9	.20	2.2	3.3	C1	Jan. 3, 1976
76003	1646	59.05	46-41.27	119-13.91	2.60	2.38	8	189	19.2	.16	1.3	1.3	C1	Jan. 3, 1976
76005	2350	1.78	46-40.76	119-13.18	2.50		12	125	20.5	.15	.7	1.0	C1	Jan. 5, 1976
76011	335	49.20	47-40.07	120- .48	8.70	2.03	6	113	15.6	.49	4.5	12.6	C1	Jan. 11, 1976
76011	1213	50.80	46-41.39	118-52.09	1.04		6	281	37.6	.03	.6	.4	C1	Jan. 11, 1976
76014	027	23.96	45-39.40	118-55.98	3.00	2.31	11	189	14.2	.36	3.1	4.1	D1	Jan. 14, 1976
76015	1837	19.70	46-40.72	119-13.80	3.20	1.92	9	123	19.8	.13	.6	1.2	B1	Jan. 15, 1976
76016	1825	32.08	48-18.87	119-56.86	3.00	2.30	7	272	41.5	.12	2.3	3.9	C1	Jan. 16, 1976
76017	2 7	47.22	46-25.90	119-15.29	3.90		8	117	2.6	.12	.5	1.2	B1	Jan. 17, 1976
76017	240	2.17	46-25.76	119-15.17	2.60	1.80	8	118	2.7	.09	.6	.8	B1	Jan. 17, 1976
76017	2358	48.16	46-40.67	119-13.46	1.90	1.81	7	189	20.1	.09	.8	37.8	D1	Jan. 17, 1976
76021	2059	55.21	45-56.01	119-21.47	2.40	1.73	6	131	11.0	.15	.6	1.0	C1	Jan. 21, 1976
76022	2346	39.21	45-39.08	118-56.85	3.00	2.34	7	194	15.1	.16	2.3	3.8	C1	Jan. 22, 1976
76029	829	18.19	46-25.78	119-14.80	1.10	2.47	14	100	3.2	.15	.6	1.1	B1	Jan. 29, 1976
76035	2035	35.82	47-56.88	119- 2.44	.43		9	162	10.6	.44	1.6	3.0	C1	Feb. 4, 1976
76036	040	53.34	45-55.30	119-17.86	1.50		7	103	11.5	.38	2.0	2.8	C1	Feb. 5, 1976
76037	011	47.69	45-38.56	118-52.57	11.60	2.20	8	188	9.5	.29	2.2	2.1	C1	Feb. 6, 1976
76041	016	18.01	47-58.07	118-58.84	4.50	2.18	8	188	12.9	.09	1.0	1.0	C1	Feb. 10, 1976
76043	2147	6.28	46- 7.63	119-28.10	.60	2.47	16	131	16.7	.19	.8	1.0	C1	Feb. 12, 1976
76045	124	59.18	45-55.41	119-19.17	1.50	2.09	7	113	10.9	.28	1.3	1.6	C1	Feb. 14, 1976
76048	1954	36.90	46-50.25	119-50.72	4.67	2.08	10	156	17.2	.23	1.2	1.5	C1	Feb. 17, 1976
76049	2259	51.70	47-57.38	118-59.40	1.65	2.08	10	224	12.9	.56	7.0	7.4	D1	Feb. 18, 1976
76054	2120	10.76	46- 7.87	119-27.06	.56	2.39	13	126	15.4	.33	.7	1.1	C1	Feb. 23, 1976
76059	1728	20.43	46-53.58	119-56.24	1.43	2.40	7	301	24.6	.13	2.3	2.6	C1	Feb. 28, 1976
76061	2310	43.73	46- 9.32	118-38.39	2.30	2.53	14	134	25.8	.13	.5	.8	B1	Mar. 1, 1976
76061	2310	45.21	46-14.23	118-40.70	3.00		6	311	88.9	.25	3.7	2.6	D1	Mar. 1, 1976
76063	2018	11.05	48- 1.68	118-57.21	.32	2.27	10	223	13.7	.56	4.6	3.8	D1	Mar. 3, 1976
76064	2020	54.43	48- 1.42	118-56.44	.07	2.13	8	221	14.7	.56	5.5	4.3	D1	Mar. 4, 1976
76067	1459	59.69	46-52.84	119-34.35	18.90	2.28	10	133	4.0	.24	1.7	3.0	B1	Mar. 7, 1976
76068	2013	24.51	47-58.67	118-57.84	.19	2.15	9	195	13.7	.51	3.6	3.8	D1	Mar. 8, 1976
76069	753	51.53	46- 3.88	118-55.86	11.60	1.92	7	146	2.2	.18	2.2	2.1	C1	Mar. 9, 1976
76070	043	26.62	48- .39	118-56.96	3.94	2.37	12	212	14.1	.41	4.3	2.7	D1	Mar. 10, 1976
76075	1 8	36.96	46-26.32	119-15.27	2.14	1.74	7	175	2.7	.06	.4	1.0	B1	Mar. 15, 1976
76075	1224	10.12	46-38.72	119-37.84	2.32	2.08	11	189	24.2	.13	.6	2.2	C1	Mar. 15, 1976
76076	3 8	47.36	46-38.89	119-37.80	.90	2.06	15	75	10.7	.09	.3	1.1	B1	Mar. 16, 1976
76076	631	9.68	46-39.01	119-38.46	4.85	1.84	10	118	10.0	.17	.8	1.3	C1	Mar. 16, 1976
76077	3 3	36.41	46-26.09	119-15.01	1.33	2.05	8	119	2.9	.08	.5	.8	B1	Mar. 17, 1976
76077	836	36.09	46-38.94	119-37.90	6.19	1.43	7	114	10.7	.07	.4	.4	B1	Mar. 17, 1976
76078	249	9.72	47-34.43	117-40.53	.63	2.43	6	305	42.0	.19	3.0	2.4	D1	Mar. 18, 1976
76078	330	2.59	47-46.81	119-31.12	1.23	1.99	8	140	12.4	.46	2.7	4.3	C1	Mar. 18, 1976
76079	1122	15.83	46-38.79	119-37.60	1.15	1.96	10	111	10.9	.12	.5	2.0	B1	Mar. 19, 1976
76082	1223	20.69	46-26.18	119-14.95	2.26	2.27	13	98	3.0	.12	.4	.6	B1	Mar. 22, 1976
76083	445	22.14	46-38.90	119-37.55	.41	2.22	11	75	11.1	.10	.4	.8	B1	Mar. 23, 1976
76086	047	37.90	47-49.49	118- 7.80	1.54	2.12	7	273	22.0	.17	4.1	3.2	D1	Mar. 26, 1976
76086	148	7.34	47-57.34	118-57.63	.07	2.18	8	230	14.9	.31	2.5	2.9	D1	Mar. 26, 1976
76089	638	49.43	47-40.56	120- 8.78	5.77	2.39	9	159	16.7	.23	1.4	1.1	C1	Mar. 29, 1976
76090	845	16.65	46-39.09	119-38.10	1.66	2.12	13	75	10.5	.11	.4	.7	B1	Mar. 30, 1976