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onr ltr, 28 jul 1977

LONG RANGE SEISMIC MEASUREMENTS

GREELEY

20 DECEMBER 1966

Prepared for

AIR FORCE TECHNICAL APPLICATIONS CENTER

Washington, D. C.

28 APRIL 1967

By

TELEDYNE INC.

Under

Project VELA UNIFORM

Sponsored By

ADVANCED RESEARCH PROJECTS AGENCY

Nuclear Test Detection Office

ARPA Order No. 624

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LONG RANGE SEISMIC MEASUREMENTS

GREELEY

20 December 1966

SEISMIC DATA LABORATORY REPORT NO. 180

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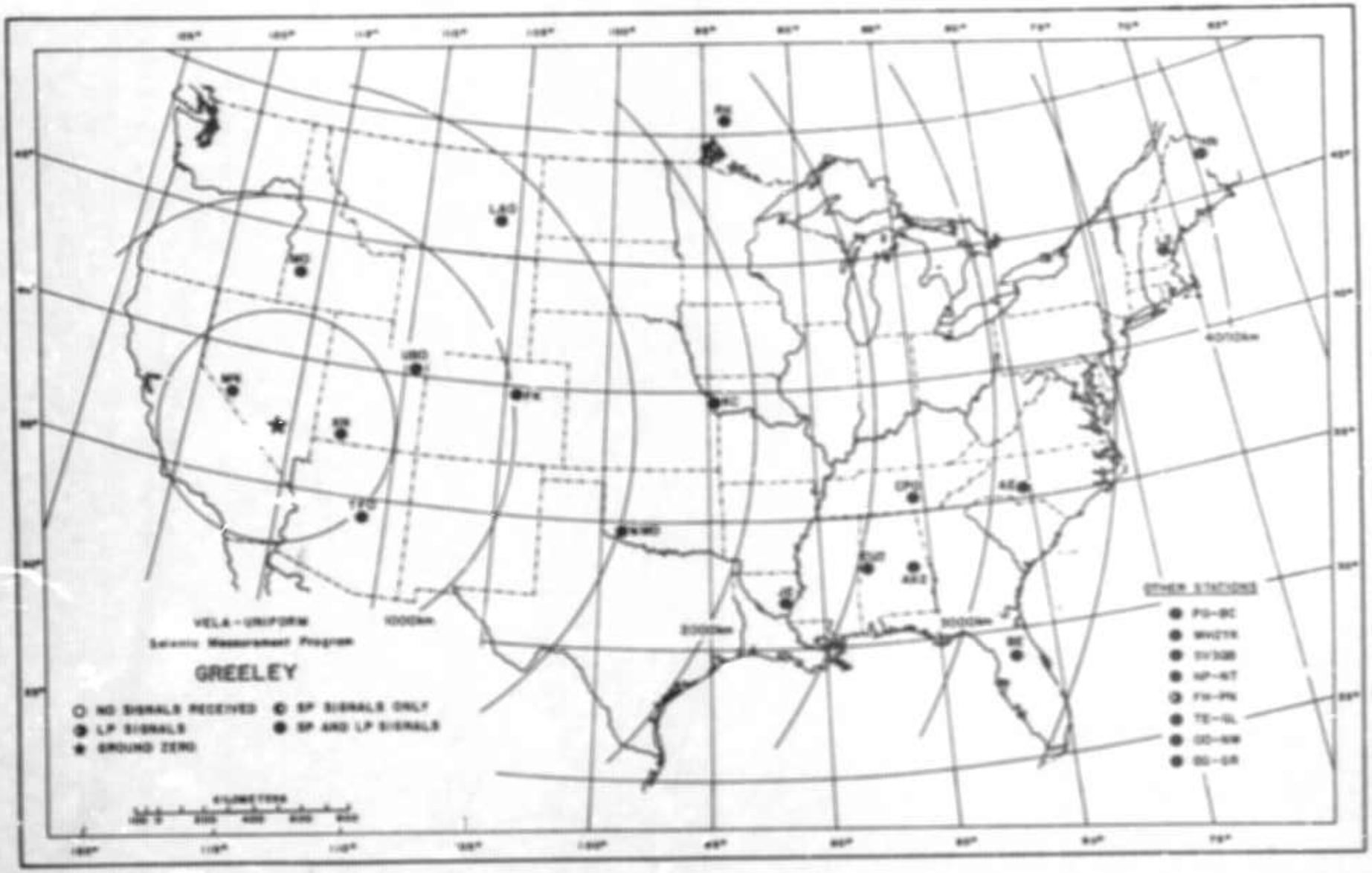
GREELEY

EVENT DESCRIPTION

DATE:	20 December 1966
TIME OF ORIGIN:	15:30:00.1Z
YIELD:	
MAGNITUDE:	6.29 ± 0.45
LOCATION:	
SITE:	Nevada Test Site, Area U20g
	GEOGRAPHIC COORDINATES:
	Lat: 37°18'07.0" N
	Long: 116°24'30.0" W
ENVIRONMENT:	
	GEOLOGIC MEDIUM: ZEOLITIZED TUFF
	SURFACE ELEVATION: 6470 ft.
	SHOT ELEVATION: 2430 ft.
	SHOT DEPTH: 4040 ft.
COMPUTED EPICENTER:	
	ALL STATIONS
	GEOGRAPHIC COORDINATES:
	Lat: 37°14'56.4" N
	Long: 116°31'44.4" W
	TIME OF ORIGIN: 15:30:00.4
	DEPTH CONSTRAINED TO: 0 km
	EPICENTER SHIFT: 12.2 km, S 61° W



Recording Stations and Signals Recieved.

Figure 1

INTRODUCTION

A long range seismic measurements (LRSM) program and several larger seismographic observatories were established under VELA-UNIFORM to record seismological data resulting from natural seismic activity and a planned series of U. S. underground nuclear tests. The LRSM teams are mobile and occupy locations selected to provide optimum data from events of special interest; the observatories are permanent installations as follows:

Wichita Mountains Seismological Observatory (WMSO)
Lawton, Oklahoma

Uinta Basin Seismological Observatory (UBSO)
Vernal, Utah

Cumberland Plateau Seismological Observatory (CPSO)
McMinnville, Tennessee

Tonto Forest Seismological Observatory (TFSO)
Payson, Arizona

Large Aperture Seismic Array (LASA)
Billings, Montana

The purpose of this report is to provide an analysis of data resulting from the GREELEY event recorded by the LRSM teams and the VELA observatories and a preliminary summary of data reported by other permanent and temporary seismographic stations.

INSTRUMENTATION AND PROCEDURE

The instrumentation at each of the LRSM locations consists of three-component short-period and three-component long-period seismographs. In general, data are recorded on 35 millimeter film and on one-inch 14 channel magnetic tape, although recently more portable instrumentation has been incorporated which records only on magnetic tape. The stations are all equipped to record WWV continuously to provide accurate time control and calibration is accomplished once each day and just prior to each shot at the operational settings. Pertinent information useful for analysis of LRSM data is available to qualified users of this data and is contained in Technical Report 65-43, "Interpretation and Usage of Seismic Data, LRSM program." General information on LRSM van and portable system equipment and operation is given in Technical Report 66-27, "The LRSM Mobile Seismological Laboratory," and 65-74, "A Portable Seismograph." Copies of these reports may be obtained from DDC. The AD control number of Technical Report 66-27 is 480343. All the observatories have both long-period and short-period, three-component instrumentation, in addition to their other specialized facilities.

Station information is presented in Appendix I. This includes the station name and code; the geographic coordinates,

distances and azimuths involved; the station elevations; and the type of instruments in use at each location. Representative instrumental response curves are shown in Appendix II(B) and II(C).

The procedures used in measuring amplitudes reported herein are illustrated in Appendix II(A) and the unified magnitude is calculated as shown in Appendix I'B). The distance factors (B) beyond 16° are from Gutenberg and Richter*. For distances less than 16° values were read from a curve in the Gutenberg and Richter paper back to 10° and then extrapolated to 2°, using an inverse cube relationship. An additional magnitude for less than 16° was computed using a method described by Evernden**. (Figure 3).

A standard hypocenter location program for a digital computer is used to determine the location using data from all stations analyzed. Best-fit values of latitude, longitude, and time of origin are determined statistically by a least squares technique. This utilizes a Jeffreys-Bullen travel-time curve as modified by Herrin in 1961 on the basis of Pacific surface-focus recordings. Precision of the computation is limited primarily by the accuracy of arrival times, the validity of the standard travel-time curve, and by local velocity deviations. This method is based on P-wave

* Gutenberg, B. and Richter, C. F., Magnitude and Energy of Earthquakes, Ann. Geofis., 9 (1956), pp. 1-15

** Evernden, J. F., Magnitude Determination at Regional and Near Regional Distances in the United States, AFTAC/VELA Seismological Center Technical Report VU-65-4A, (1965), pp.6, 13

arrivals with the depth constrained to zero.

DATA AND RESULTS (LRSM AND VELA OBSERVATORIES)

The parameters of the GREELEY event and a summary of the seismic evaluation is shown on the Event Description page. The operational status of the 26 LRSM stations and observatories is given in Table 1 and illustrated in Figure 1.

Table 2 summarizes the measurements made of the principal phases from the GREELEY event at the LRSM and VELA stations. Included are the Pn and P arrival times, the maximum amplitudes (A/T) of Pn or P motion and other phases as seen on the short-period vertical instruments. Long-period Love and Rayleigh wave motion are also tabulated in (A/T) form. In addition, individual station Rayleigh wave areas (mm^2) is indicated as measured on the LPZ only. Although reduced to 1K magnification, they have not been normalized to any magnitude. Twenty-five stations recorded short-period signals. Long-period signals from this event were recorded by 26 stations.

The unified magnitudes determined from the LRSM and VELA observatories is shown in Figure 2. The average magnitude is 6.29 $\pm$ 0.45. The adjusted magnitude is 6.16 $\pm$ 0.40 and is shown in

Figure 3.

The travel-time residuals from the Pn and P phases are shown in Figure 4. Figures 5 through 9 illustrate plots of the amplitudes of P, Pg, Lg, LQ, and LR.

Attached to the report are illustrative seismograms showing the signals recorded at 4 stations. The most distant station analyzed that recorded GREELEY was GG-GR at a distance of 9095 kilometers.

Principal Phases
GREELEY
20 December 1966
15:30:00.12

Code	Station	Distance (km)	Inst.	Magnification (k) Film x 10	Phase	Observed Travel Time (min)	Observed Travel Time (sec)	Period T (sec)	Maximum Amplitude A/T	Magnitude mb	Magnitude ms	Area (mm²) LPZ
MN-NV	Mina, Nevada	190	SPZ	0.17	Pn	0	31.7	0.4	26590	4.62	6.25	
			SPZ	0.048*	Pg	0	33.1	0.4	170730			
			SPT	0.176	Lg			1.0	100975			
			LPT		LQ			---	---			
			LPZ	0.0376	LR			(9.5)	(4240841)			142,245.99
KN-UT	Kanab, Utah	320	SPZ	0.116	Pn	0	47.0	0.4	4032	6.50	6.44	
			SPZ	0.116	P?	0	53.7	0.55	74170			
			SPT	0.142	Lg			1.2	115000			
			LPT		LQ			---	---			
			LPZ	0.0495	LR			(1.7	88101			21,333.33
TFSO	Tonto Forest Observatory, Arizona	572	SPZ-60	2.0	Pn	1	19.7	(0.4)	(11120)	(6.40)	(6.36)	
			SPZ-60	2.0	(P?)	1	27.1	0.5	2032			
			SPZ-60	10.7*	Pg	1	35.2	0.7	5214			
			SPN	1.00	Lg			(1.0)	(10637)			
			SPE	1.00	Lg			(1.2)	(4493)			
			LPN	0.125	LQ			13.0	2542			
			LPE	0.125	LQ			(13.0)	(1464)			
			LPZ	7.09	LR			15.0	14933			7,309.54
MO-ID	Mountain Home, Idaho	641	SPZ	2.73	Pn	1	28.4	0.7	(7300)	(5.99)	(5.61)	
			SPZ	2.73	e	1	30.4	0.9	1155			
			SPZ	2.73	e	1	32.0	1.0	2060			
			SPZ	2.73	PP	1	35.1	0.8	1490			
			SPZ	2.73	Pg	1	44.5	1.0	29304			
			SPT	0.0159*	Lg			1.1	33737			
			LPT	0.139*	LQ			11.0	34201			
			LPZ	0.146*	LR			13.0	9179			2,950.80
UBSO	Uinta Basin Observatory, Utah	682	SPZ-10	0.4	Pn	1	(35.0)	1.0	2750	7.20	7.13	
			SPZ-10	0.4	Pg	1	53.3	(0.6)	(7600)			
			SPN	0.444	Lg			1.4	13967			
			SPE	0.50	Lg			1.4	7300			
			LPN	0.3*	LQ			15.0	9800			
			LPE	0.51*	LQ			15.0	5106			
			LPZ	2.1*	LR			17.0	995			1,097.14
FR-CO	Franktown, Colorado	1073	SPZ	29.9	Pn	2	22.6	0.8	636	7.19	5.71	
			SPZ		Pg	3	(01.4)	---	---			
			SPT		Lg			---	---			
			LPT	0.458	LQ			(13.0)	(20360)			
			LPZ	0.156	LR			13.0	7330			3,441.54
LAO	Dubberry, (AO-10) Montana	1340	SPZ		Pn	3	12.5	--	---			
			LPZ	2.16	LR			17.0	935			812.50
WMSO	Wichita Mountain Observatory, Oklahoma	1429	SPZ-6	7.0	P	3	30.4	1.5	1429	6.56	6.30	
			SPZ-6	7.0	e	3	55.7	1.4	817			
			SPZ-6	7.0	(Pg)	4	34.7	1.1	2097			
			LPN	3.0	S	6	20	15.0	238			
			LPE	3.0	S	6	[illegible]	13.0	248			
			SPN	6.0	Lg			1.9	3000			
			SPE	6.0	Lg			1.6	1303			
			LPN	1.0*	LQ			(15.0)	(2010)			
			LPZ	0.36	LR			16.0	9963			3,750.00
KC-MO	Kansas City, Missouri	1717	SPZ	11.8	P	4	41.4	1.1	976	5.80		
			SPZ	11.8	e	4	49.3	(1.1)	(1060)			
			SPZ	11.8	PP	4	16.0	1.2	1107			
			SPZ	11.8	e	5	24.5	1.4	1066			
			LPN	1.40	S	7	17	17.0	272			
			LPT	2.14	S	7	17	13.0	326			
			SP?	11.8	Lg			1.6	900			

			LPZ	2.0	[illegible]	[illegible]	[illegible]	12.0	[illegible]				
			SPN	4.0	Lg			1.9	2800				
			SPZ	4.0	Lg			1.6	1700				
			LPN	1.04	LQ			(15.0)	(2020)				
			LPZ	0.10	LR			14.9	5543				3,750.00
KC-MO	Kansas City, Missouri	1957	SPZ	11.0	P	4	71.4	1.3	976	5.04			
			SPZ	11.0	[illegible]	4	65.3	(1.1)	(1060)				
			SPZ	11.0	PP	4	10.0	1.2	1107				
			SPZ	11.0	[illegible]	5	24.5	1.4	1066				
			LPN	3.40	S	7	17	12.5	270				
			LPZ	2.14	S	7	17	12.0	324				
			SPN	13.7	Lg			1.4	900				
			SPZ	10.1	Lg			1.0	1839				
			LPN	0.9[illegible]	LQ			15.0	5017				
			LPZ	0.723*	LQ			15.0	9330				
			LPZ	0.220	LR			11.0	7934				3,664.91
PG-BC	Prince George, British Columbia, Canada	1915	SPZ	13.0	P	6	73.5	1.4	896	5.65			
			SPZ	13.0	[illegible]	6	66.0	1.4	3674				
			SPZ	13.0	PP	6	10.0	1.2	540				
			SPZ	13.0	[illegible]	6	18.9	1.5	1273				
			LPN	2.43	S	7	22	(21.0)	(1111)				
			LPZ	1.30	S			(23.0)	(81.3)				
			SPN	11.5	Lg			2.3	1154				
			SPZ	13.0	Lg			2.3	790				
			LPN	2.49	LQ			13.0	3711				
			LPZ	1.04	LQ			11.0	4216				
			LPZ	0.5	LR			11.0	3111				2,600.00
JE-LA	Jena, Louisiana	2316	SPZ	12.0	P	4	(40.7)	1.0	3050	6.99			
			SPZ	12.0	[illegible]	4	33.1	1.0	2147				
			SPZ	12.0	PP	5	05.0	1.3	792				
			LPN	1.03	S	8	30	13.0	1005				
			LPZ	1.33	S	8	30	13.0	806				
			SPN	13.42	Lg			1.0	7543				
			SPZ	13.42	Lg			1.0	3972				
			LPN	1.03	LQ			13.0	2140				
			LPZ		LQ			---	---				
			LPZ	0.30	LR			12.0	13000				8,333.00
RK-ON	Red Lake, Ontario Canada	2366	SPZ	12.0	P	6	65.4	(1.3)	(1960)	(6.40)			
			SPZ	12.0	[illegible]	6	48.4	1.8	4106				
			SPZ	12.0	[illegible]	4	55.7	1.5	1763				
			LPZ	5.05	S	8	63	(20.0)	(60.0)				
			SPZ	11.9	Lg			1.8	757				
			LPZ	3.95	LQ			16.0	777				
			LPZ	0.504	LR			13.0	3197				1,369.06
BHSAL	Boaz, Alabama	2439	SPZ	50.3	P	5	10.0	(1.0)	(165)	(5.52)			
			SPZ	50.3	[illegible]	5	30.1	(1.5)	(349)				
			SPZ	50.3	[illegible]	5	42.4	1.2	192				
			SPZ	50.3	PP	5	60.6	1.3	102				
			LPN	3.3	S	9	36	12.0	433				
			LPZ	8.06	S	9	36	17	320				
			SPN	50.2	Lg			2.6	573				
			SPZ	41.7	Lg			(2.2)	(429)				
			LPN	3.3	LQ			18	1960				
			LPZ	4.06	LQ			18	871				
			LPZ	0.495	LR			17	1642				3,424.34
CPOO	Cumberland Plateau Observatory, Tennessee	2799	SPZ-8	35.0	P	5	24.3	0.9	442	6.11			
			LPN	5.5	S	9	40	(20.0)	(83.5)				
			LPN	5.5	S			18.0	158				
			SPN	25.3	Lg			2.0	1113				
			SPZ	25.0	Lg			1.7	406				
			LPN	0.23	LQ			14.0	9438				

Principal Phases - GREELEY

Table 2 Page 1

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Principal Phases
GREELEY
20 December 1966
15:30:00.1Z

Code	Station	Distance (km)	Inst.	Magnification (k) Film x 10	Phase	Observed Travel Time (min)	Observed Travel Time (sec)	Period T (sec)	Maximum Amplitude A/T	Magnitude mb	Magnitude Ms	Area (mm^2) Lfi
			LPE	0.25	LQ			14.0	1645			
			LPZ	0.25	LR			14.0	5863			4,560.00
AX2AL	Alexander City, Alabama	2796	SPZ	12.5	P	5	28.0	1.2	1045	6.51		
			SPZ	12.5	e	5	30.2	(1.3)	(1521)			
			SPZ	12.5	e	5	38.1	1.2	688			
			LPR	6.14	S	9	55	16	236			
			LPT	3.04	S	9	55	17	152			
			SPR	12.8	Lg			2.0	444			
			SPT	12.7	Lg			(2.4)	(974)			
			LPR	6.14	LQ			23	599			
			LPT	3.04	LQ			21	1137			
			LPZ	0.234	LR			(16)	(2472)			5,491.45
WH2YK	Whitehorse, Yukon Territory, Canada	2913	SPZ	16.7	P	5	36.7	1.0	135	5.55		
			SPZ	16.7	e	5	38.7	0.9	(126)			
			SPT	17.1	Lg			2.6	657			
			LPT	1.08	LQ			18	2348			
			LPZ	1.41	LR			.3	4348			5,223.40
AE-NC	Albemarle, North Carolina	3249	SPZ	21.5	P	6	03.2	1.3	552	6.34		
			SPR	21.0	e	6	19.3	1.3	253			
			SPZ	21.5	e	6	48.2	1.2	197			
			SPT	17.0	Lg			2.4	1651			
			LPT	1.32*	LQ			13	1664			
			LPZ	1.24*	LR			16	1974			1,951.61
BE-FL	Belleview, Florida	3318	SPZ	23.1	P	6	(09.9)	1.3	651	6.41		
			SPZ	23.1	e	6	16.2	1.0	162			
			SPZ	23.1	e	6	26.3	1.2	223			
			SPZ	23.1	e	6	42.4	1.6	303			
			SPZ	23.1	e	7	03.5	1.2	238			
			SPZ	23.1	(PCP)	9	28.1	1.1	216			
			LPR	1.53	S	11	15	20	108			
			LPT	1.0	S	11	15	20	102			
			SPR	21.4	Lg			1.8	387			
			SPT	20.8	Lg			1.8	277			
			LPR	1.53	LQ			17	1088			
			LPT	1.0	LQ			(17)	241)			
			LPZ	1.83	LR			17	1961			4,642.08
LS-NH	Lisbon, New Hampshire	3788	SPZ	25	P	6	46.2	1.0	535	6.43		
			SPZ	25.0	e	6	48.2	1.0	530			
			SPR	28.5	e	6	56.2	1.0	167			
			SPZ	25.0	e	7	09.4	1.4	357			
			SPT	35.5	Lg			1.8	592			
			LPT	0.36	LQ			16	2225			
			LPZ	0.33	LR			10	6774			2,015.15
HN-ME	Houlton, Maine	4082	SPZ	17.7	P	7	08.9	1.1	770	6.42		
			SPZ	17.7	e	7	15.9	1.2	486			
			SPZ	17.7	PCP	9	31.2	1.0	70.6			
			SPT	16.5	Lg			2.5	589			
			LPT	1.93	LQ			16.0	2064			
			LPZ	2.19	LR			14.0	898			1,176.08

LS-NH	Lisbon, New Hampshire	3788	SPZ	25	P	6	46.2	1.0	535	6.43		
			SPZ	25.0	a	6	48.2	1.0	530			
			SPR	28.5	e	6	56.2	1.0	167			
			SPZ	25.0	a	7	09.4	1.4	357			
			SPT	35.5	Lg			1.8	592			
			LPT	0.36	LQ			16	2225			
			LPZ	0.33	LR			10	6774			2,015.15
HN-ME	Houlton, Maine	4082	SPZ	17.7	P	7	08.9	1.1	770	6.42		
			SPZ	17.7	e	7	15.9	1.2	486			
			SPZ	17.7	PCP	9	31.2	1.0	70.6			
			SPT	16.5	Lg			2.5	589			
			LPT	1.93	LQ			16.0	2064			
			LPZ	2.19	LR			14.0	898			1,178.08
SV3QB	Schaffarvilla, Quebec Canada	4195	SPZ	15.6	P	7	16.3	(1.3)	(508)	(6.21)		
			SPZ	15.6	e	7	18.6	1.1	301			
			SPZ		PP	8	45.2	1.2	397			
			SPR	16.5	Lg			1.8	218			
			SPT	16.4	Lg			1.8	176			
			LPR	7.65	LQ			18.0	146			
			LPT	7.4	LQ			17.0	145			
			LPZ	4.75	(LR)			13	838			2,936.84
NP-MT	Mould Bay, Northwest Territorias, Canada	4344	SPZ		P	7	29.1	---	---			
			SPZ	76.6*	e	7	42.9	1.0	176			
			SPZ	236	a	8	35.1	1.3	92.6			
			SPZ		(PP)	8	57.0	---	---			
			SPZ	76.6*	(PPP)	9	19.7	1.8	261			
			SPZ	76.6*	(PCP)	9	39.7	1.0	97.9			
			SPT	121*	Lg			2.6	793			
			LPT		LQ			---	---			
			LPZ	0.88	LR			13	780			
FH-PM	Fort Sharman, Panama	4789	LPT	1.55	LQ			22	138			
			LPZ	1.55	LR			21	217			1,248.37
TE-GL	Thula, Greenland	4956	SPZ	71	P	8	12.8	1.4	152	5.79		
			SPZ	71	(PCP)	8	55.2	0.8	24.0			
			SPZ	71	(PP)	9	55.9	(1.7)	(231)			
			SPT	67	Lg			2.8	262			
			LPT	1.48	LQ			17	925			
			LPZ	1.72	LR			13	747			1,416.91
OO-NW	Oslo, Norway	8120	SPZ	58.5	P	11	30.6	0.9	88.1	5.84		
			SPZ	58.5	a	11	32.1	0.9	86.3			
			SPZ	58.5	e	11	36.3	0.8	34.6			
			SPZ	58.5	PCP	11	47.9	1.0	55.6			
			SPZ	58.5	e	14	57.9	1.8	92.3			
			LPZ	13.2	[illegible]anic R			23	55.4			
			LPZ	13.2	LR			19	129			461.36
GG-GR	Grafenberg, Germany	9095	SPZ	**	P	12	21.1					
			LPZ	**	LR							

A/T mμ/sec

() Doubtful Values or Phases

* Measurements Made from Playouts

--- Maximum Amplitudes Clipped on Film and Tape

** Magnification not available

Principal Phases - GREELEY

Table 2 Page 2

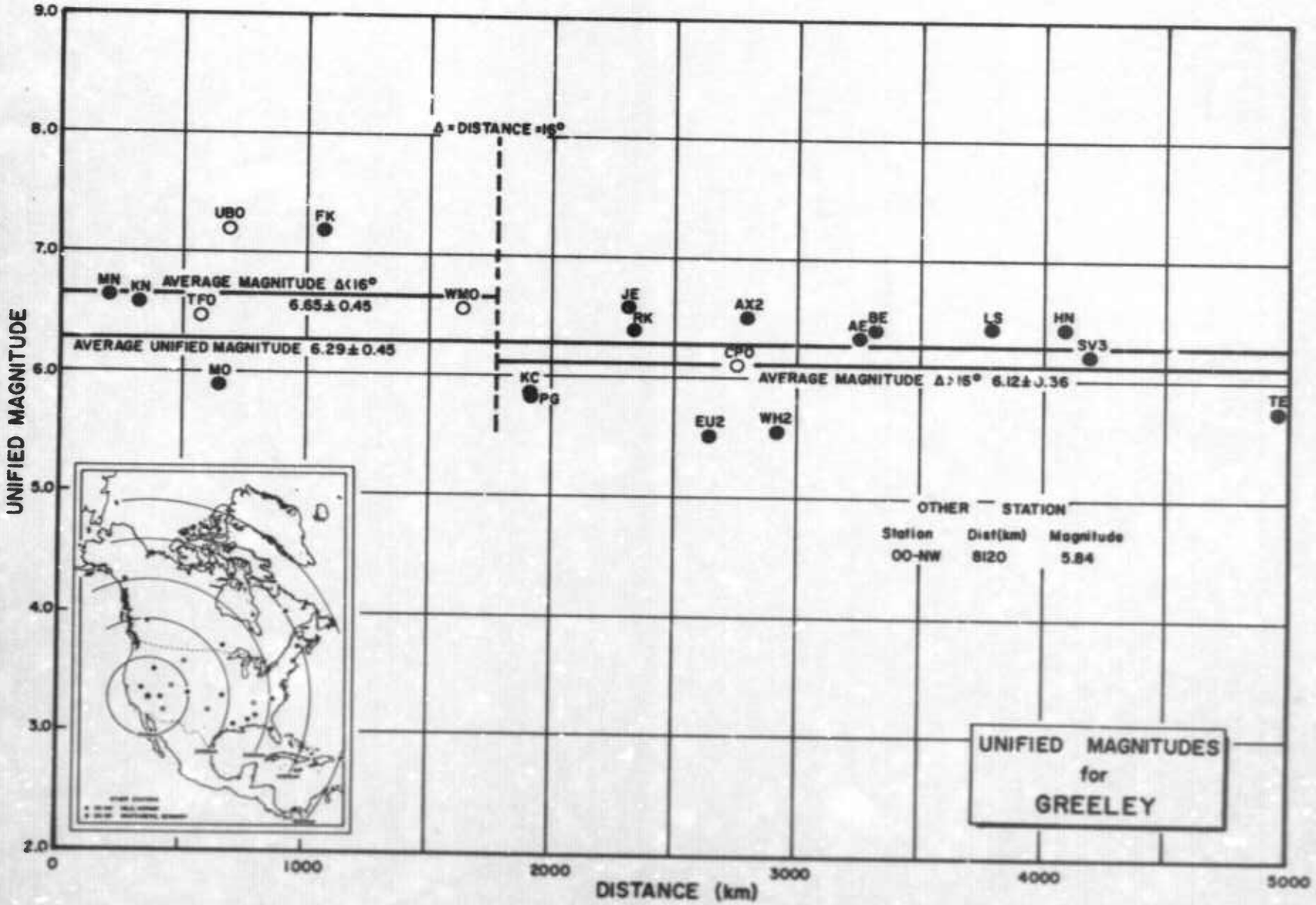
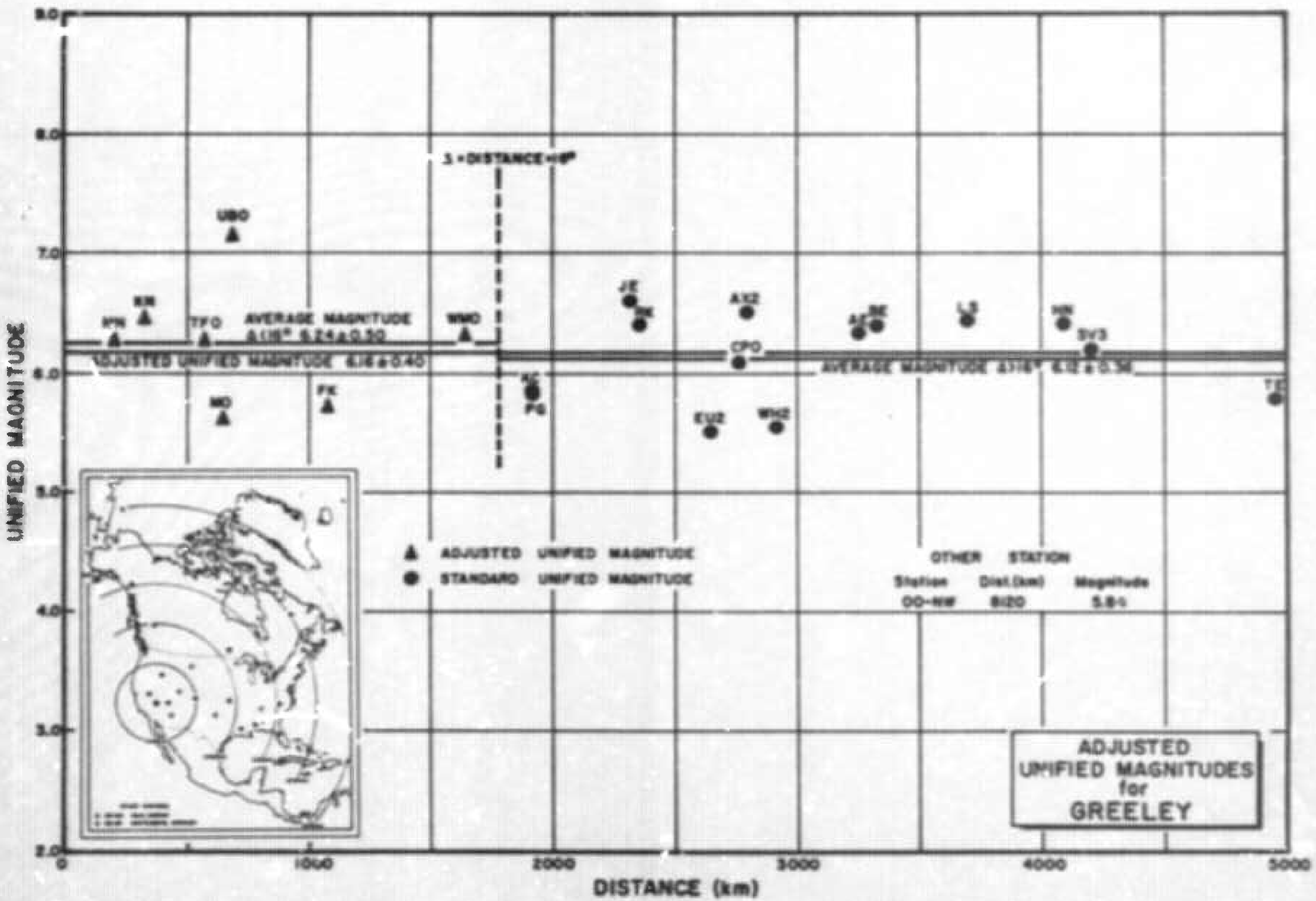

9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
UNIFIED MAGNITUDE
Δ = DISTANCE = 16°
UBO
FK
MN
KN
AVERAGE MAGNITUDE Δ<16°
6.65±0.45
TFO
WMO
JE
RK
AX2
AE
BE
LS
HN
SV3
AVERAGE UNIFIED MAGNITUDE 6.29±0.45
CPO
MO
KC
PG
AVERAGE MAGNITUDE Δ>16° 6.12±0.36
EU2
WH2
TE
OTHER STATION
Station Dist(km) Magnitude
00-NW 8120 5.84
UNIFIED MAGNITUDES
for
GREELEY
0
1000
2000
3000
4000
5000
DISTANCE (km)

Figure 2



ADJUSTED
UNIFIED MAGNITUDES
for
GREELEY
UNIFIED MAGNITUDE
DISTANCE (km)
ADJUSTED UNIFIED MAGNITUDE
STANDARD UNIFIED MAGNITUDE
OTHER STATION
Station Dist.(km) Magnitude
OO-NW 8120 5.81

Figure 3

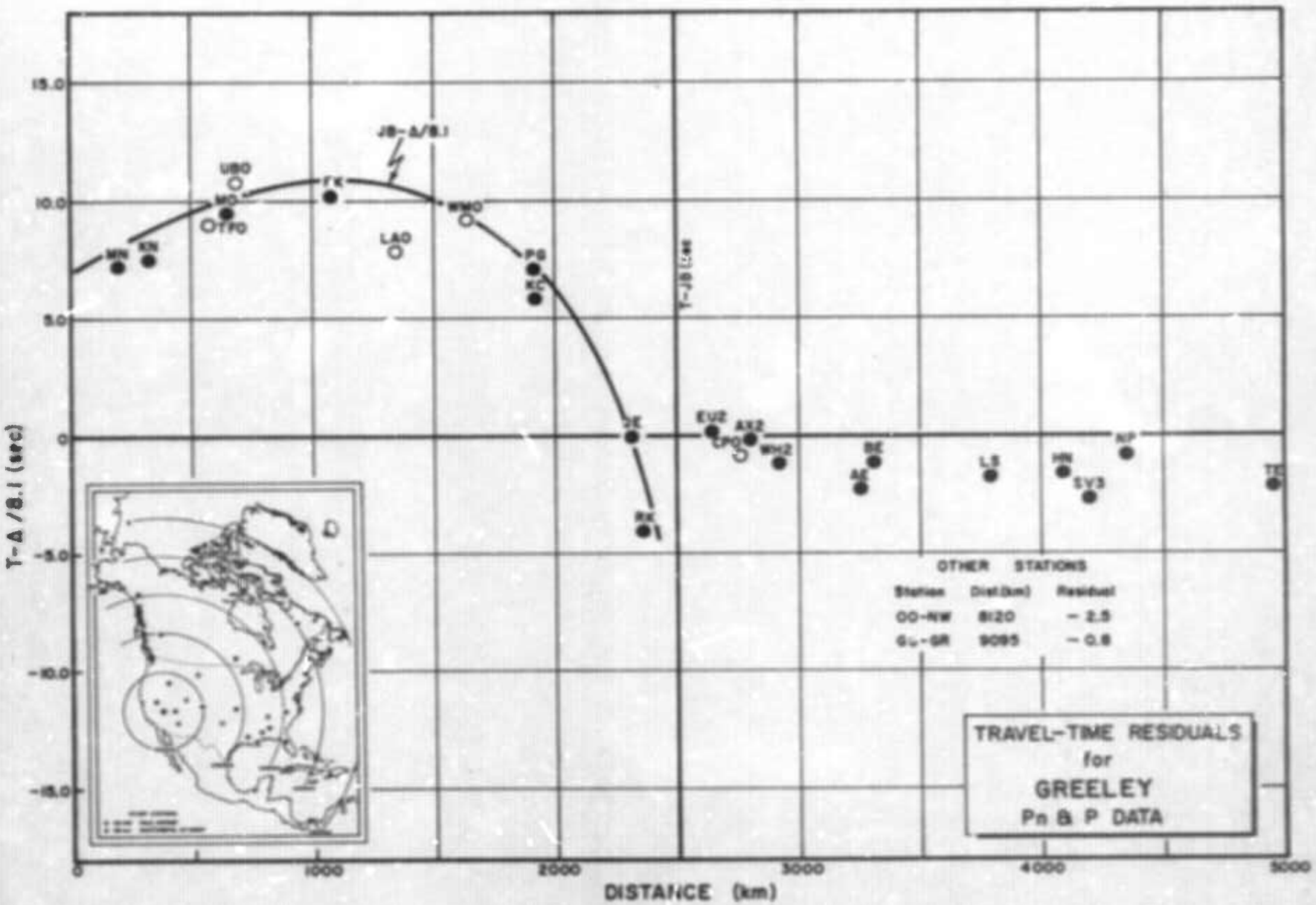

T-Δ/8.1 (sec)
15.0
10.0
5.0
0
-5.0
-10.0
-15.0
0
1000
2000
3000
4000
5000
DISTANCE (km)
JB-Δ/8.1
UBO
MO
TFO
FK
LAO
RMO
PG
KC
SE
RK
EU2
CPO
AX2
WH2
AE
BE
LS
HN
SV3
KP
TU
OTHER STATIONS
Station Dist.(km) Residual
OO-NW 8120 - 2.5
GU-GR 9095 - 0.8
TRAVEL-TIME RESIDUALS
for
GREELEY
Pn & P DATA

Figure 4

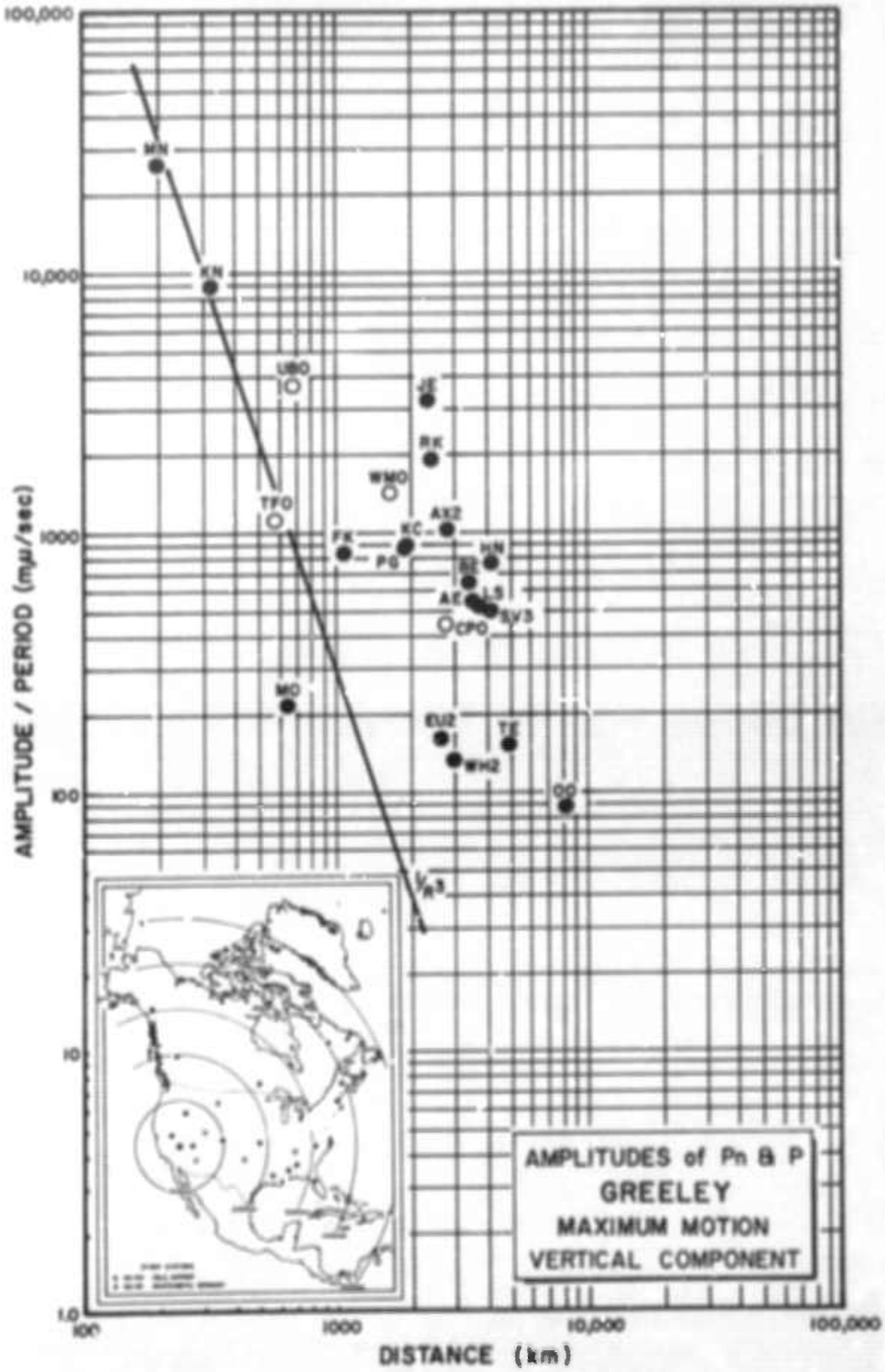

100,000
10,000
1000
100
10
1.0
AMPLITUDE / PERIOD (mμ/sec)
MN
KN
UBO
RK
WMO
TFO
AX2
FK
KC
PG
HN
AE
LS
SV3
CPO
MO
EU2
TE
WH2
OO
1/R^3
AMPLITUDES of Pn & P
GREELEY
MAXIMUM MOTION
VERTICAL COMPONENT
100
1000
10,000
100,000
DISTANCE (km)

Figure 5

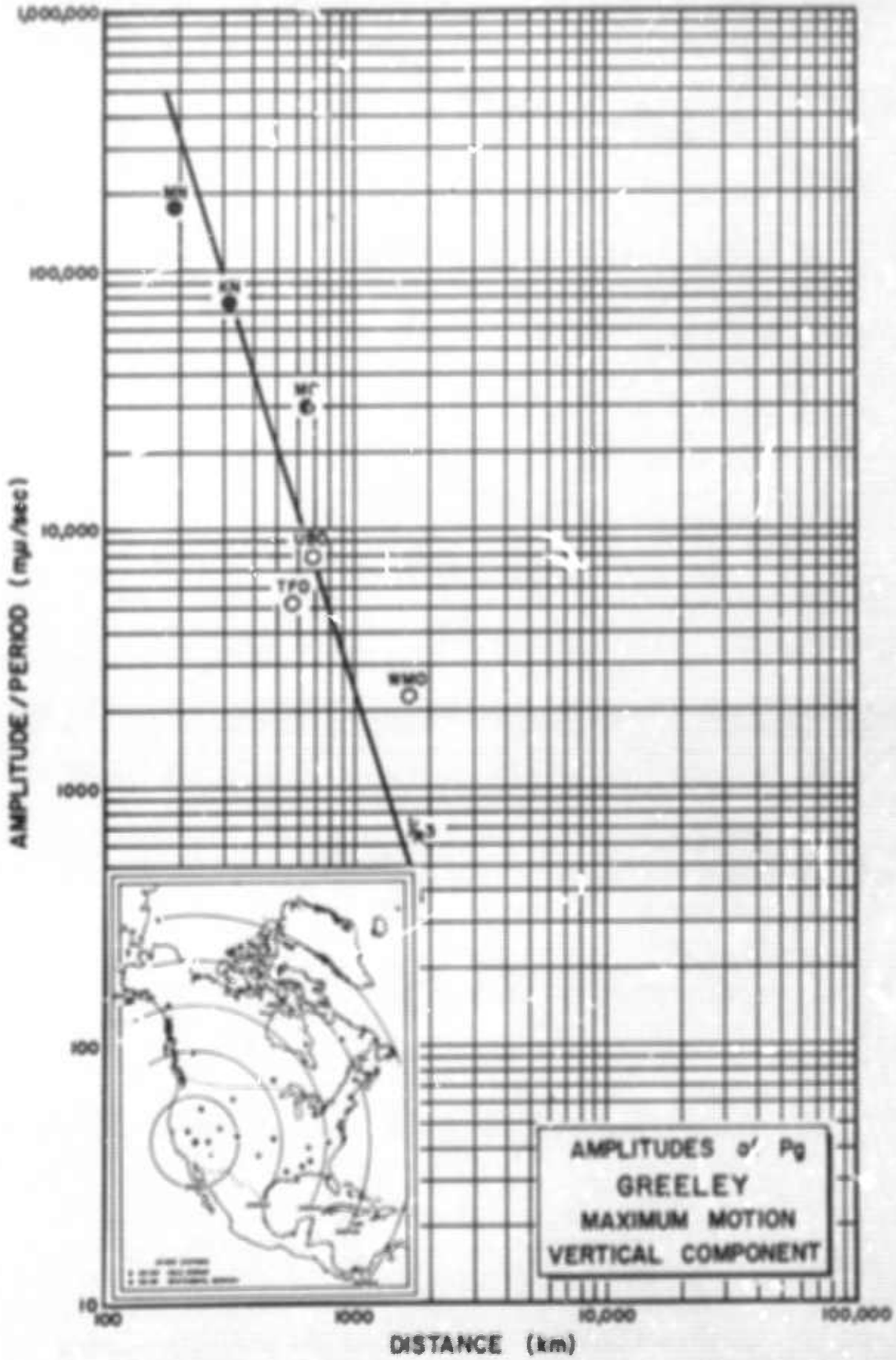

1,000,000
100,000
10,000
1000
100
10
AMPLITUDE / PERIOD (mμ/sec)
WMC
TFO
100
1000
10,000
100,000
DISTANCE (km)
AMPLITUDES of Pg
GREELEY
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 6

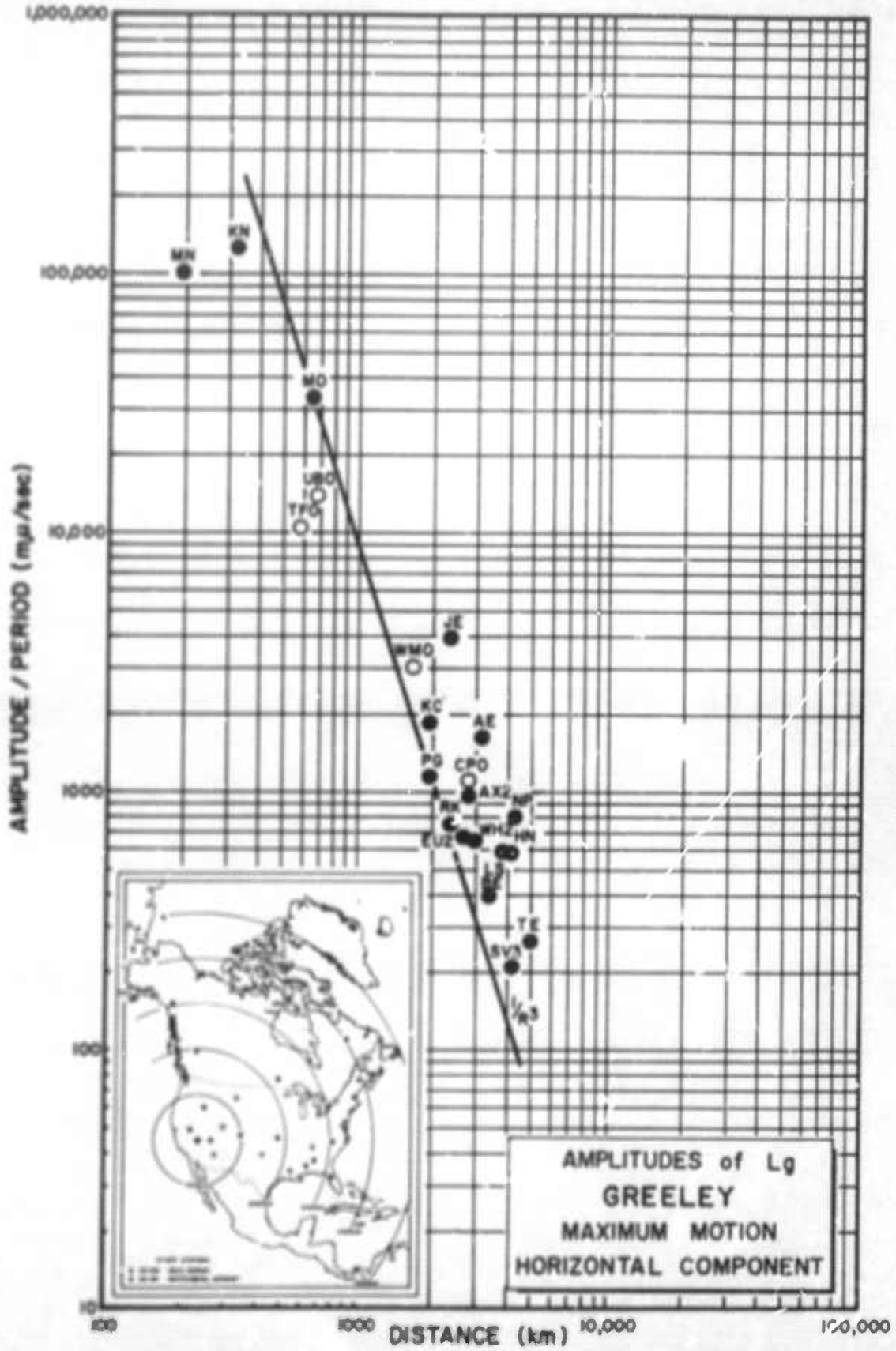

1,000,000
100,000
10,000
1000
100
10
AMPLITUDE / PERIOD (mμ/sec)
MIN
KN
MO
UBC
TFO
UE
WMO
KC
AE
PG
CPO
AX2
RK
HN
TE
SV3
1/R3
100
1000
DISTANCE (km)
10,000
100,000
AMPLITUDES of Lg
GREELEY
MAXIMUM MOTION
HORIZONTAL COMPONENT

Figure 7

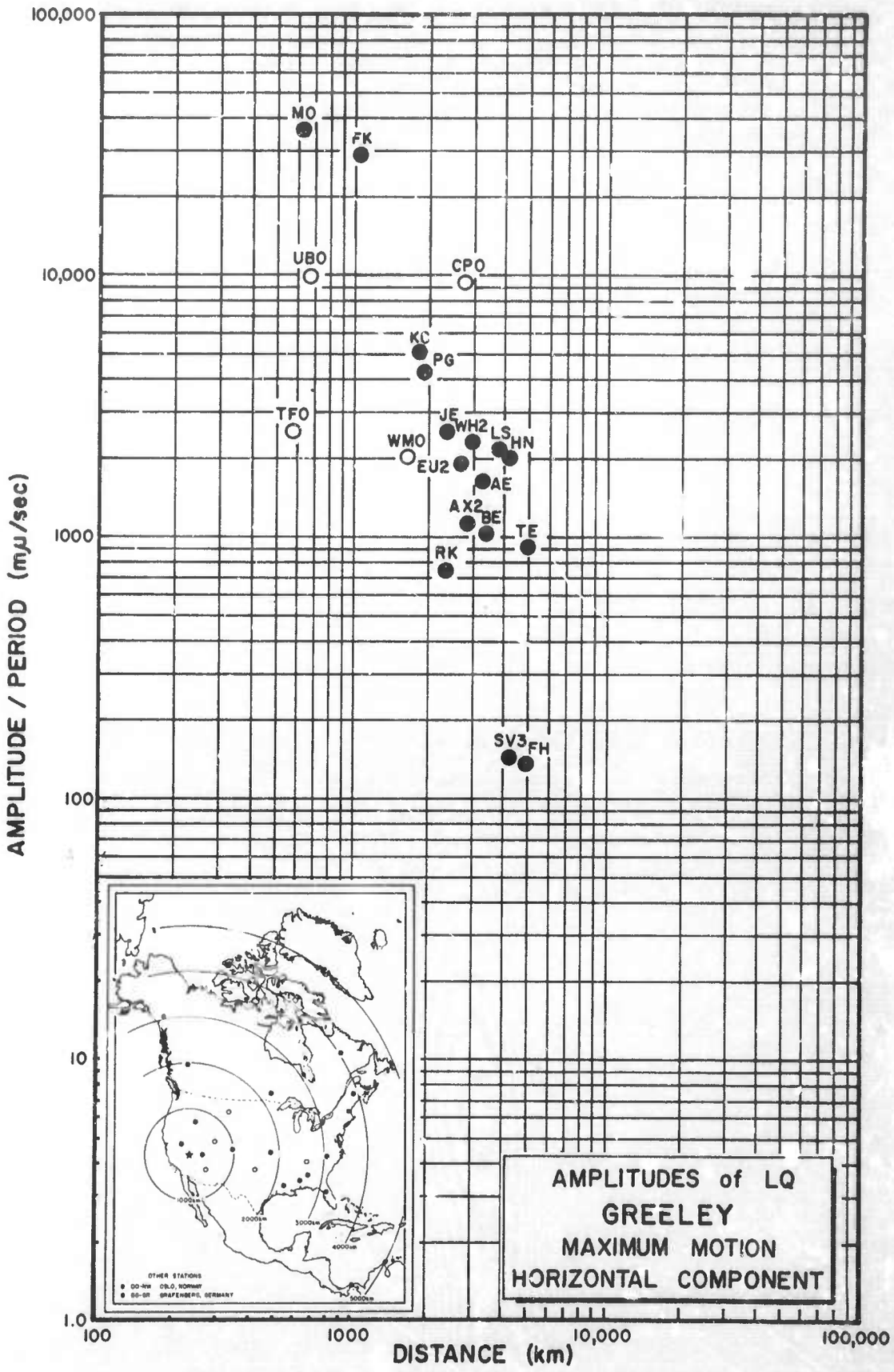

100,000
10,000
1000
100
10
1.0
AMPLITUDE / PERIOD (mμ/sec)
MO
FK
UBO
CPO
KC
PG
TFO
JE
WH2
LS
HN
WMO
EU2
AE
AX2
BE
TE
RK
SV3
FH
100
1000
10,000
100,000
DISTANCE (km)
AMPLITUDES of LQ
GREELEY
MAXIMUM MOTION
HORIZONTAL COMPONENT
OTHER STATIONS
OSLO, NORWAY
GRAFENBERG, GERMANY

Figure 8

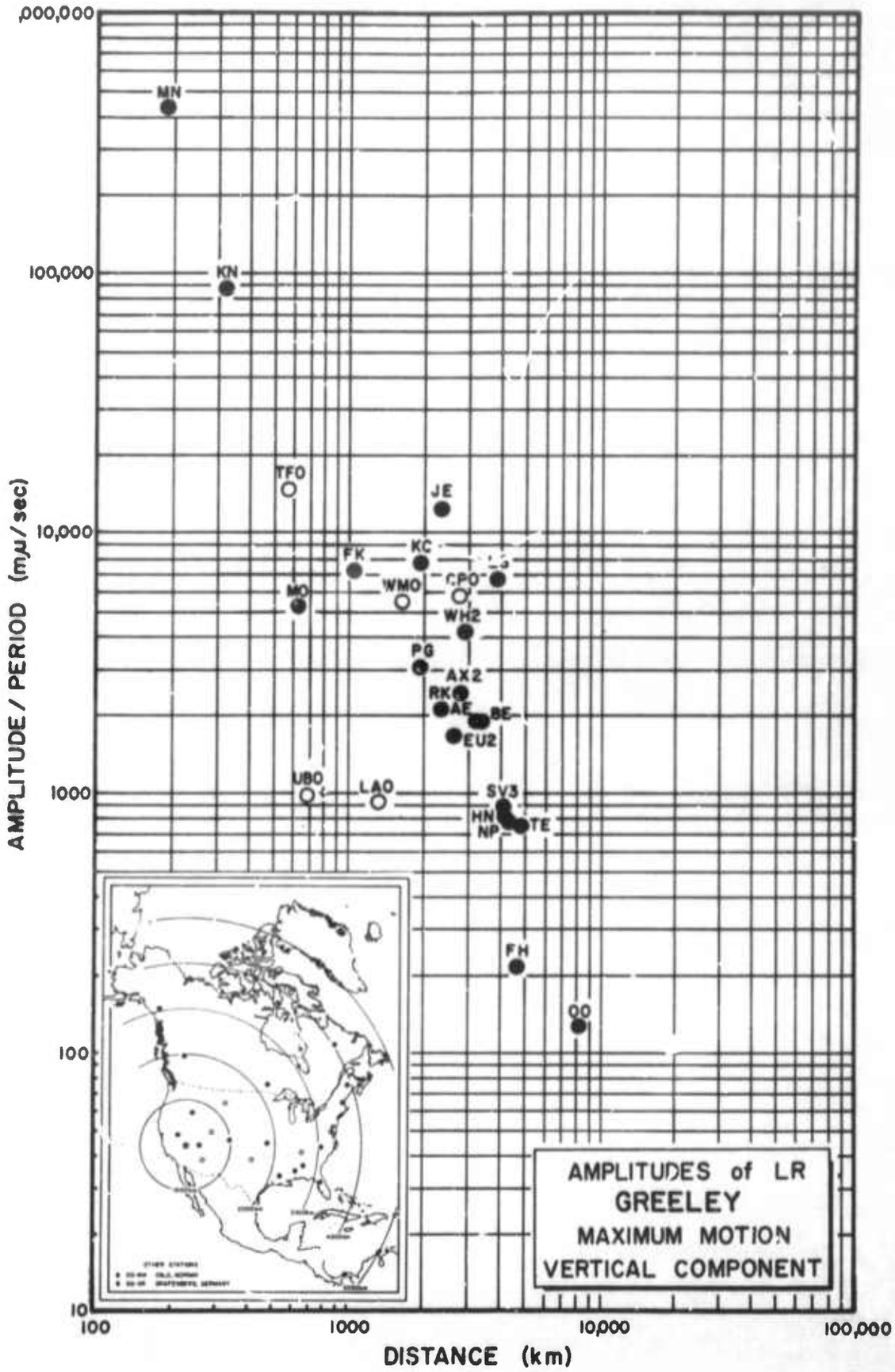

,000,000
100,000
10,000
1000
100
10
AMPLITUDE / PERIOD (mμ/sec)
MN
KN
TFO
JE
FK
KC
WMO
CPO
MO
WH2
PG
AX2
RK
AE
BE
EU2
UBO
LAO
SV3
HN
NP
TE
FH
OO
100
1000
10,000
100,000
DISTANCE (km)
AMPLITUDES of LR
GREELEY
MAXIMUM MOTION
VERTICAL COMPONENT

Figure 9

Code	Station	Distance (km)	Geographic Latitude	Geographic Longitude	Elev. (km)	Computed Azimuth		Installed Azimuth		Large or Small SP	LP Inst.
						Epi. Sta.	Sta. Epi.	Radial	Tang.		
NN-NV*	Mina, Nevada	198	38°26'10"N	118°08'53"W	1.52	310°	129°	308°	038°	L	X
NN-UT*	Kanab, Utah	320	37°01'22"N	112°49'39"W	1.74	94°	277°	95°	185°	L	X
TFSO-260	Tonto Forest Observatory, Arizona	572	34°17'13"N	111°16'03"W	1.49	134°	307°	90°	0°	JM	X
NO-ID*	Mountain Home, Idaho	541	43°04'19"N	116°15'56"W	.79	01°	181°	359°	89°	L	X
UBSO-210	Uinta Basin Observatory, Utah	683	40°19'18"N	109°34'07"W	1.60	58°	243°	90°	0°	JM	X
FK-CO*	Franktown, Colorado	1073	39°35'12"N	104°27'42"W	1.80	73°	260°	79°	169°	L	X
LAO	Bubarray AO-10,Montana	1340	46°41'19"N	106°13'30"W	.90	36°	223°			HSZ	X
WASO-26	Wichita Mountain Observatory, Oklahoma	1629	34°43'05"N	98°35'21"W	.51	95°	285°	90°	0°	JM	X
KC-MO	Kansas City, Missouri	1910	39°21'31"N	94°40'17"W	.27	76°	270°	133°	233°	S	X
PG-BC	Prince George, British Columbia, Canada	1915	53°59'50"N	122°31'23"W	.91	348°	163°	110°	200°	L	X
JE-LA	Jena, Louisiana	2314	31°47'05"N	92°00'55"W	.05	98°	302°	286°	016°	L	X
RK-ON*	Red Lake Ontario, Canada	2346	50°50'30"N	93°40'20"W	.37	43°	339°	58°	148°	S	X
EU2AL	Eutaw, Alabama	2639	32°47'47"N	87°53'05"W	.04	92°	289°	41°	131°	S	X
CPSO-28	Cumberland Plateau Observatory, Tennessee	2759	35°35'41"N	85°34'13"W	.57	85°	303°	90°	0°	JM	X
AX2AL	Alexander City, Alabama	2796	32°46'38"N	86°07'48"W	.31	91°	289°	138°	328°	L	X
WHYK*	Whitehorse, Yukon Territories, Canada	2913	60°41'41"N	134°58'02"W	.85	339°	145°	325°	055°	L	X
AE-NC*	Albemarle, North Caroline	3349	35°26'01"N	80°03'52"W	.18	83°	284°	104°	194°	Geotech	X
BF-FL	Belleview, Florida	3318	38°54'19"N	83°03'52"W	.72	96°	295°	140°	330°	S	X
LS-NH*	Lisbon,New Hampshire	3788	44°14'18"N	71°55'21"W	.29	64°	274°	94°	184°	Geotech	X
HH-ME*	Houlton, Maine	4082	46°09'43"N	67°59'09"W	.21	60°	274°	93°	183°	S	X
SV3QB	Schefferville, Quebec, Canada	4195	54°48'39"N	66°45'00"W	.58	46°	263°	139°	329°	S	X
MP-NT*	Mould Bay, Northwest Territories, Canada	4344	76°15'00"N	119°32'18"W	.06	359°	176°	356°	86°	JMZ	X
PM-PM*	Fort Sherman, Panama	4789	09°21'47"N	79°57'30"W	.03	121°	316°			Geotech	X
TE-GL*	Thule,Greenland	4956	76°29'50"N	68°36'20"W	.21	14°	237°	57°	147°	Geotech	X
OO-NW*	Oslo, Norway	8120	61°02'53"N	10°53'42"E	.56	34°	318°	138°	228°	L	X
OG-GR*	Grafenberg,Germany	9095	49°41'32"N	11°13'55"E	.53	31°	320°	140°	230°	L	X

* Seismometers Orienteted Toward Nevada Test Site

Recording Site Information - Greeley

Appendix 1 (A)

Unified Magnitude: $m = \log_{10} (A/T), + B$

where

A = zero to peak ground motion in millimicrons
$= \frac{(mm)\ (1000)}{K}$

T = signal period in seconds

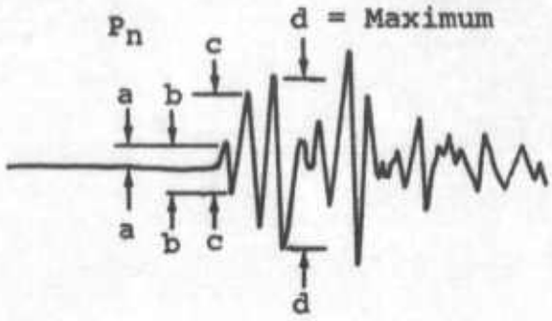
B = distance factor (see Table below)

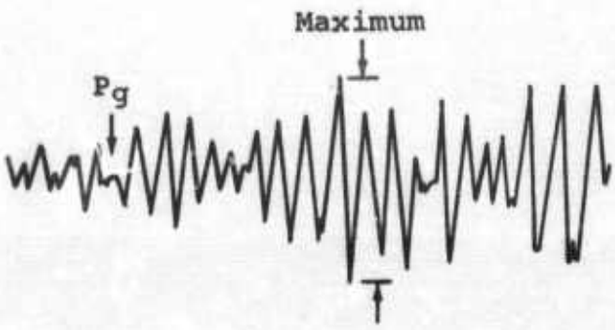
mm = record amplitude in millimeters zero to peak

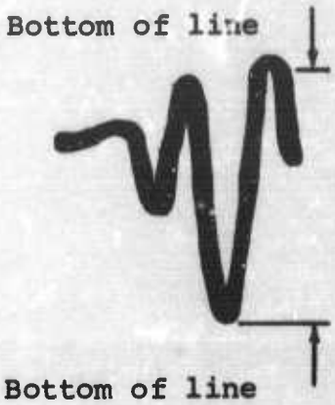
K = magnification in thousands at signal frequency

Table of Distance Factors (B) for Zero Depth

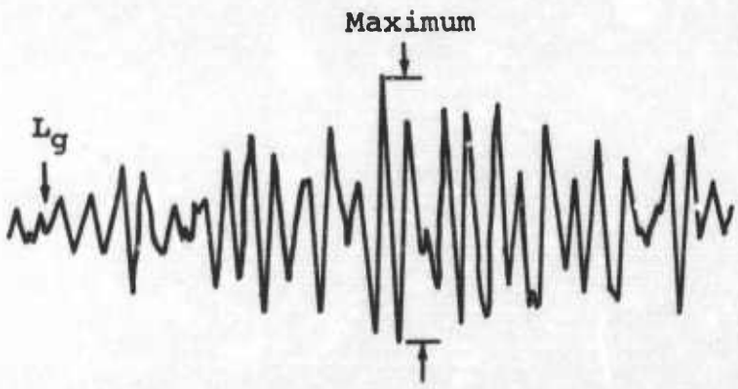
Dist (deg)	B	Dist (deg)	B	Dist (deg)	B	Dist (deg)	B
0°	-	27°	3.5	54°	3.8	80°	3.7
1	-	28	3.6	55	3.8	81	3.8
2	2.2	29	3.6	56	3.8	82	3.9
3	2.7	30	3.6	57	3.8	83	4.0
4	3.1	31	3.7	58	3.8	84	4.0
5	3.4	32	3.7	59	3.8	85	4.0
6	3.6	33	3.7	60	3.8	86	3.9
7	3.8	34	3.7	61	3.9	87	4.0
8	4.0	35	3.7	62	4.0	88	4.1
9	4.2	36	3.6	63	3.9	89	4.0
10	4.3	37	3.5	64	4.0	90	4.0
11	4.2	38	3.5	65	4.0	91	4.1
12	4.1	39	3.4	66	4.0	92	4.1
13	4.0	40	3.4	67	4.0	93	4.2
14	3.6	41	3.5	68	4.0	94	4.1
15	3.3	42	3.5	69	4.0	95	4.2
16	2.9	43	3.5	70	3.9	96	4.3
17	2.9	44	3.5	71	3.9	97	4.4
18	2.9	45	3.7	72	3.9	98	4.5
19	3.0	46	3.8	73	3.9	99	4.5
20	3.0	47	3.9	74	3.8	100	4.4
21	3.1	48	3.9	75	3.8	101	4.3
22	3.2	49	3.8	76	3.9	102	4.4
23	3.3	50	3.7	77	3.9	103	4.5
24	3.3	51	3.7	78	3.9	104	4.6
25	3.5	52	3.7	79	3.8	105	4.7
26	3.4	53	3.7				







Detail Showing Allowance
For Line Width



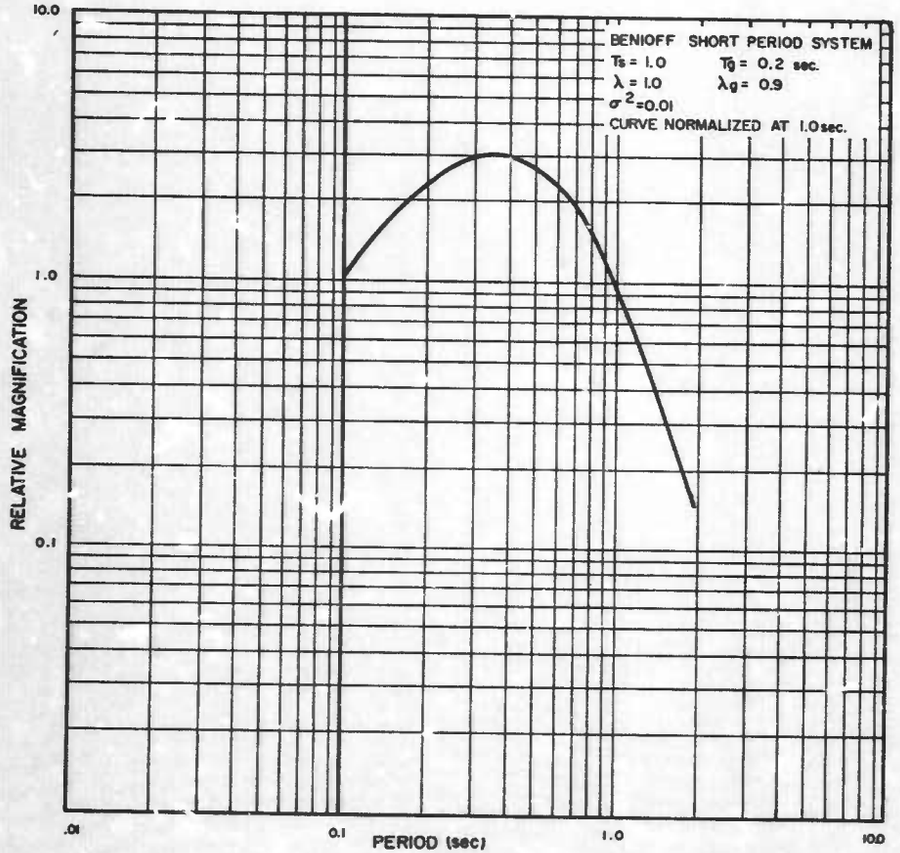
Pick <u>time</u> of <u>Pn</u> at beginning of "a" half cycle.

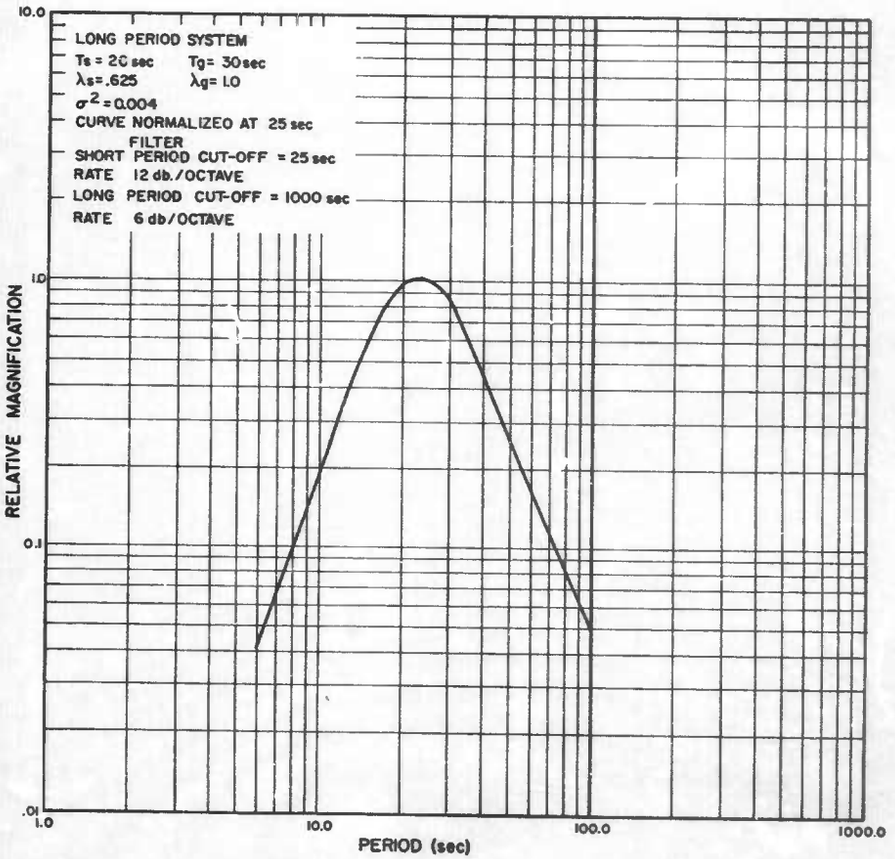
Pick <u>amplitude</u> of <u>Pn</u> as maximum "$d/2$" within 2 or 3 cycles of "c".

Pick <u>amplitudes</u> of <u>Pg</u> and <u>Lg</u> at maximum of corresponding motion.

Seismic Analysis Diagram

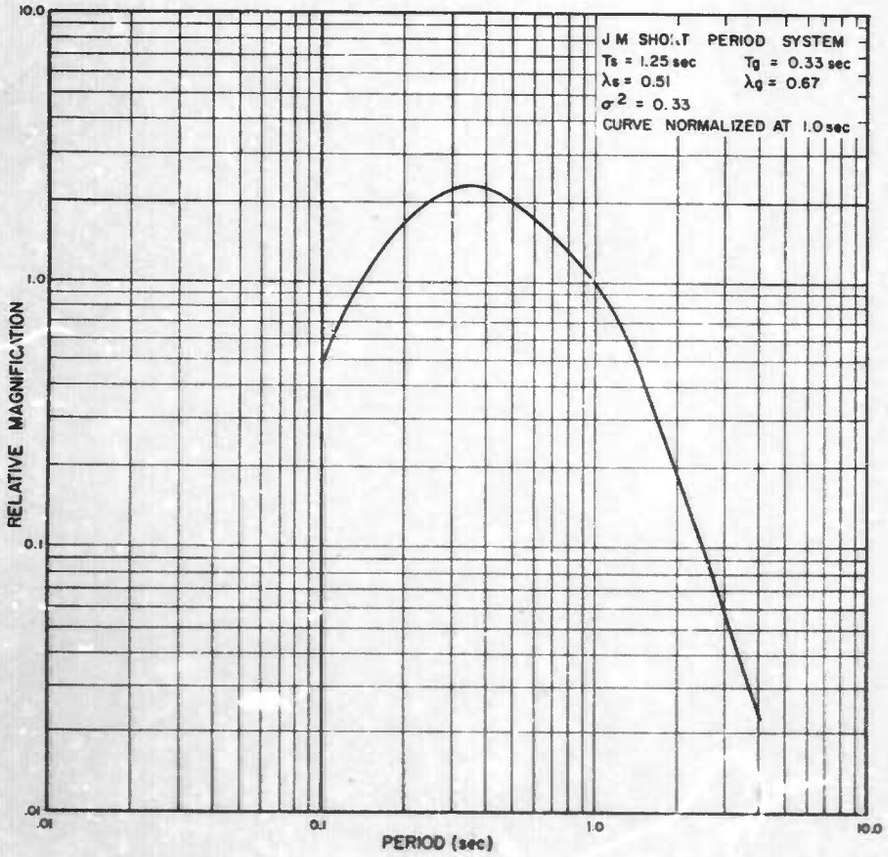
APPENDIX II(A)

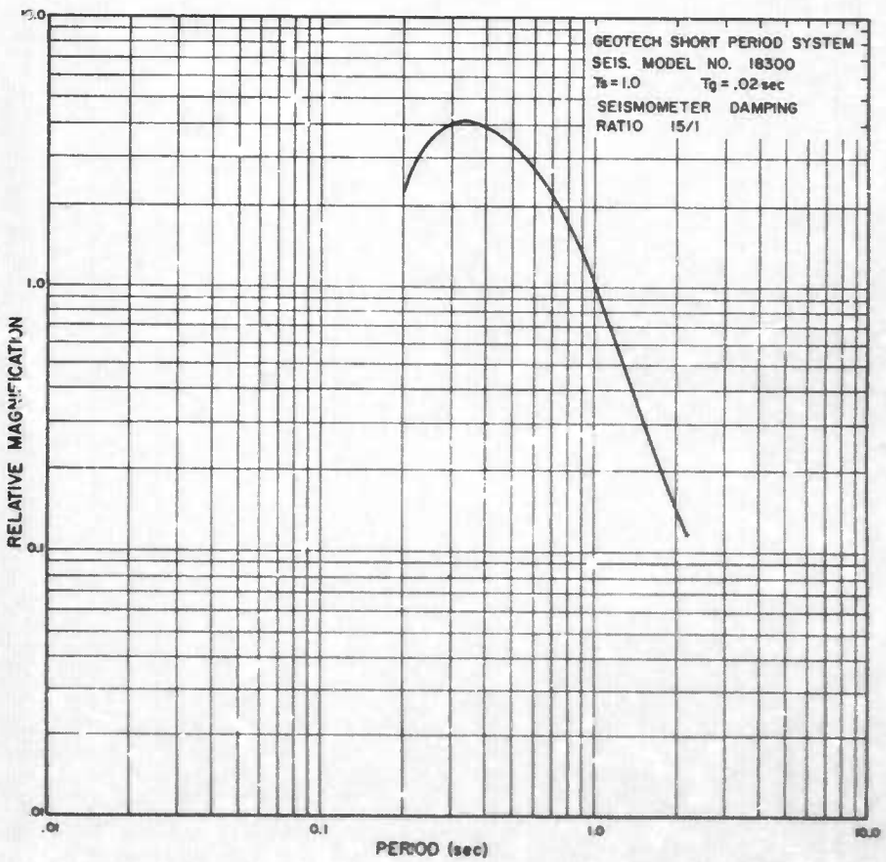




INSTRUMENT RESPONSE CURVES - LRSM

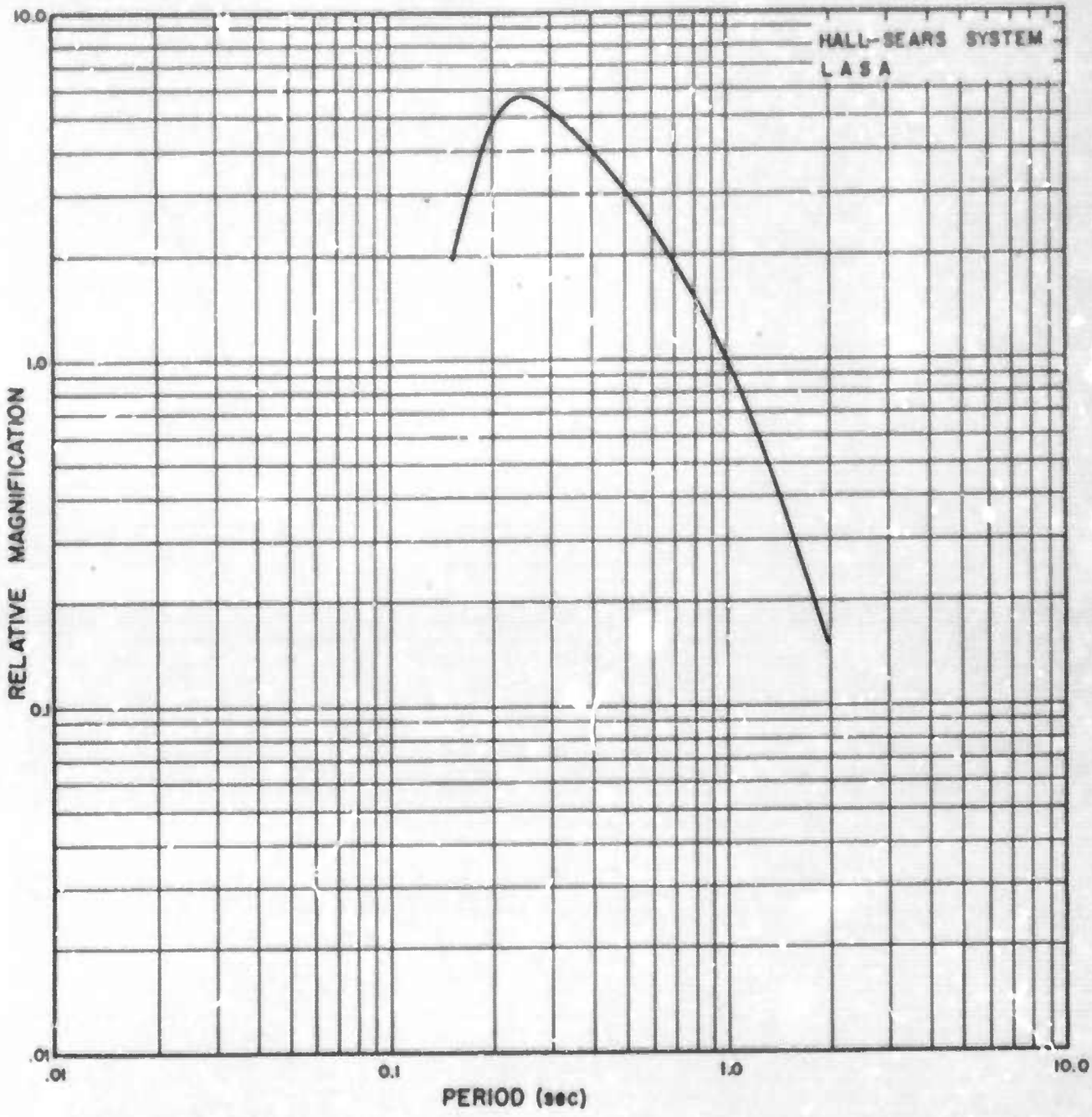
APPENDIX II(B)





INSTRUMENT RESPONSE CURVES - OTHER SHORT PERIOD

APPENDIX II(C)



INSTRUMENT RESPONSE CURVE - LASA

APPENDIX II(D)

Unclassified
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ALEXANDRIA, VIRGINIA

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP
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3. REPORT TITLE
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4. DESCRIPTIVE NOTES (Type of report and inclusive dates)
Scientific

5. AUTHOR(S) (Last name, first name, initial)
Clark, Don M.

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8d. ARPA Program Code No. 5810

9a. ORIGINATOR'S REPORT NUMBER(S)
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ADVANCED RESEARCH PROJECTS AGENCY
NUCLEAR TEST DETECTION OFFICE
WASHINGTON, D.C.

13. ABSTRACT

An analysis of seismological data from an underground nuclear explosion as a continuing study to provide information to aid in distinguishing between earthquakes and explosions. A table of travel-times and amplitudes of P, Pg, Lg, and surface waves are included along with other unidentified phases.

DD FORM 1 JAN 64 1473

Unclassified
Security Classification

Unclassified

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Sismic Magnitude						
Seismic Travel-Time						
Seismic Amplitude						
VELA-UNIFORM						
Nuclear Tests						

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GPO 866-551

Unclassified

Security Classification

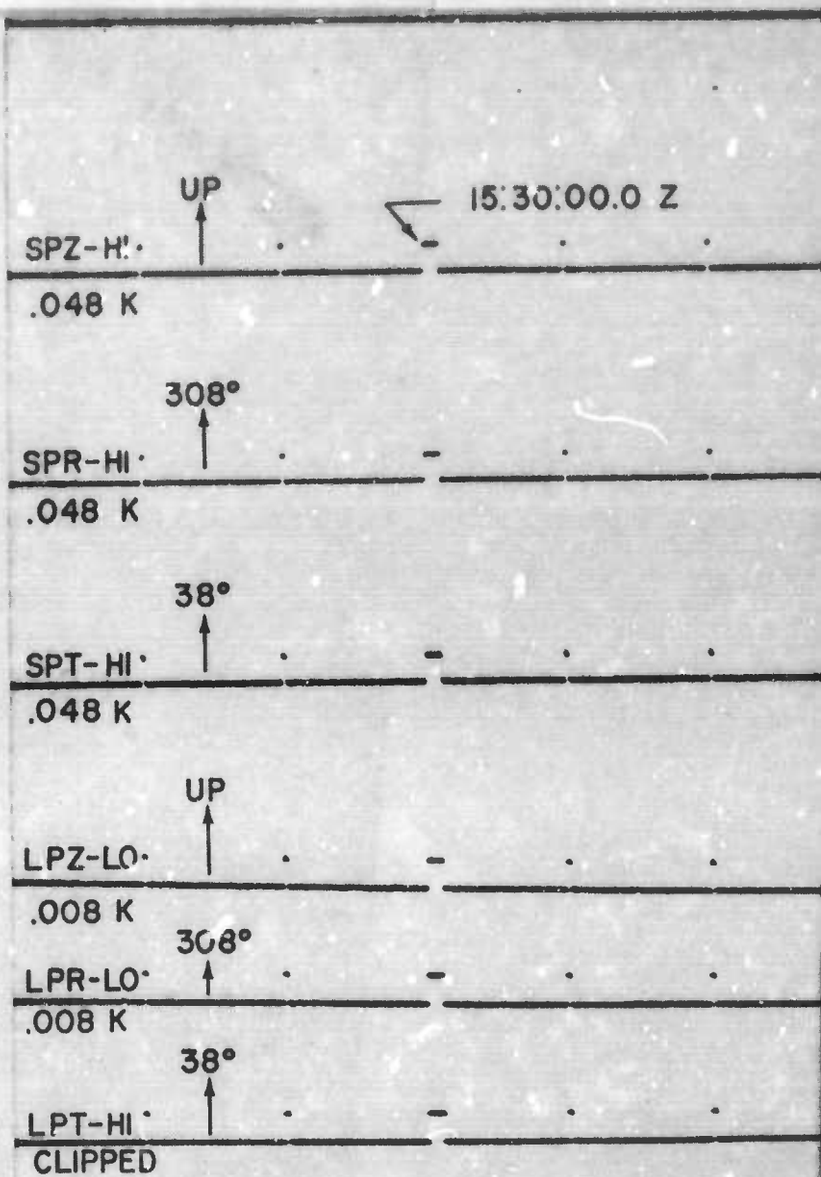
GREELEY

MN – NV

MINA, NEVADA

20 DECEMBER 1966

Δ = 198 km



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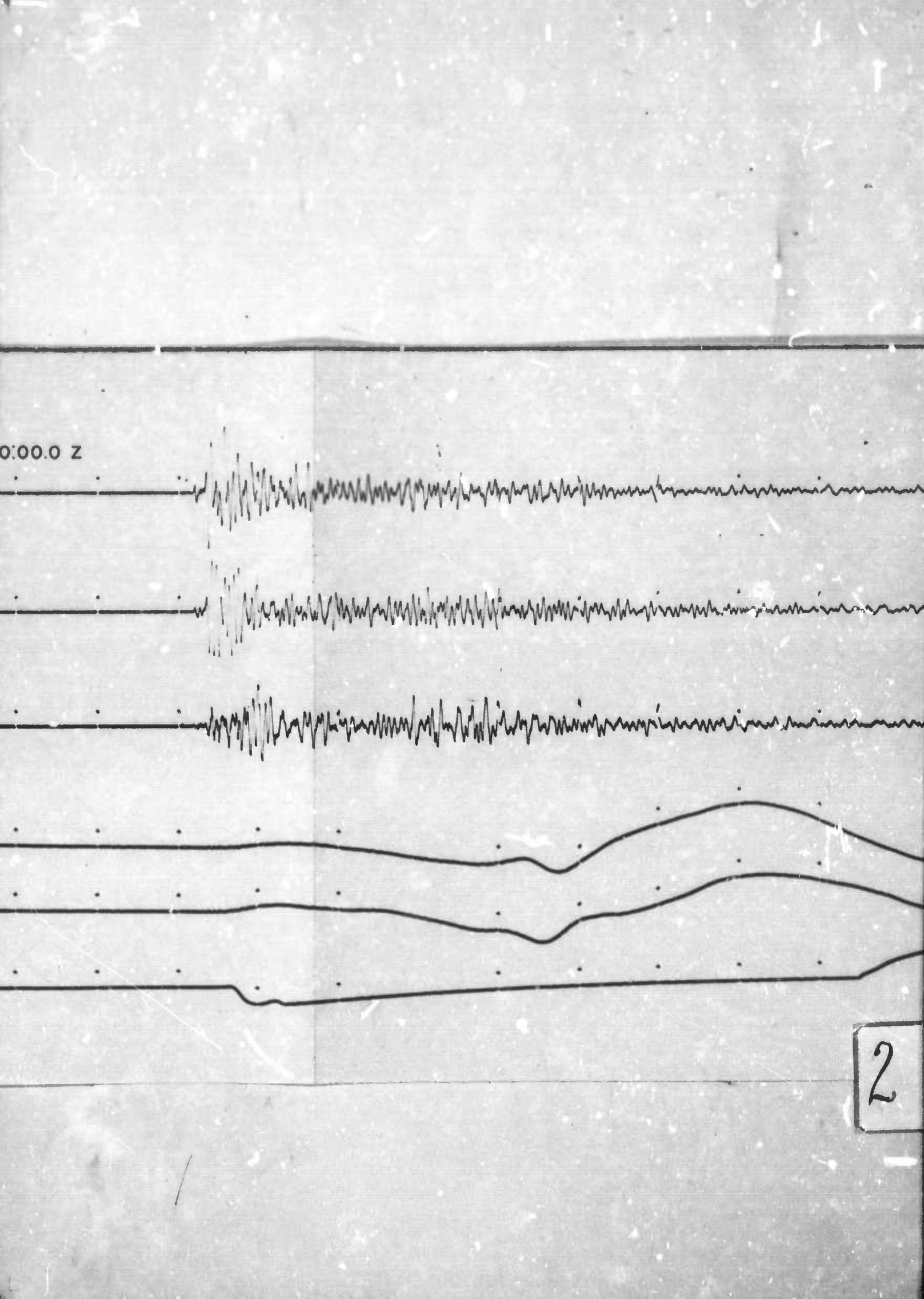
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2

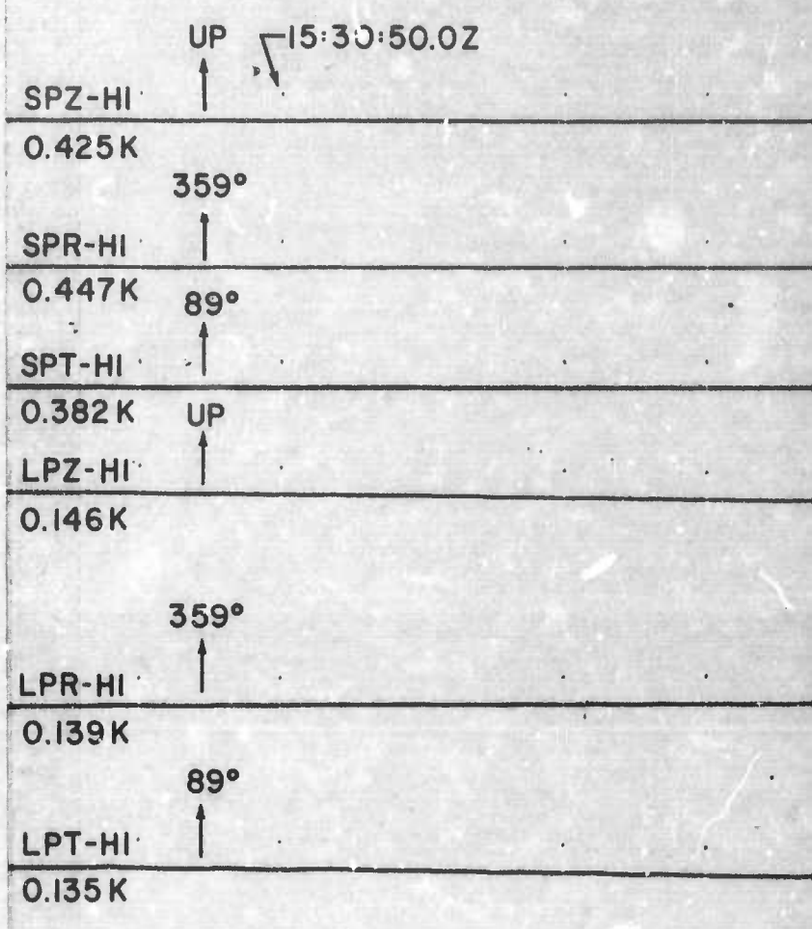
GREELEY

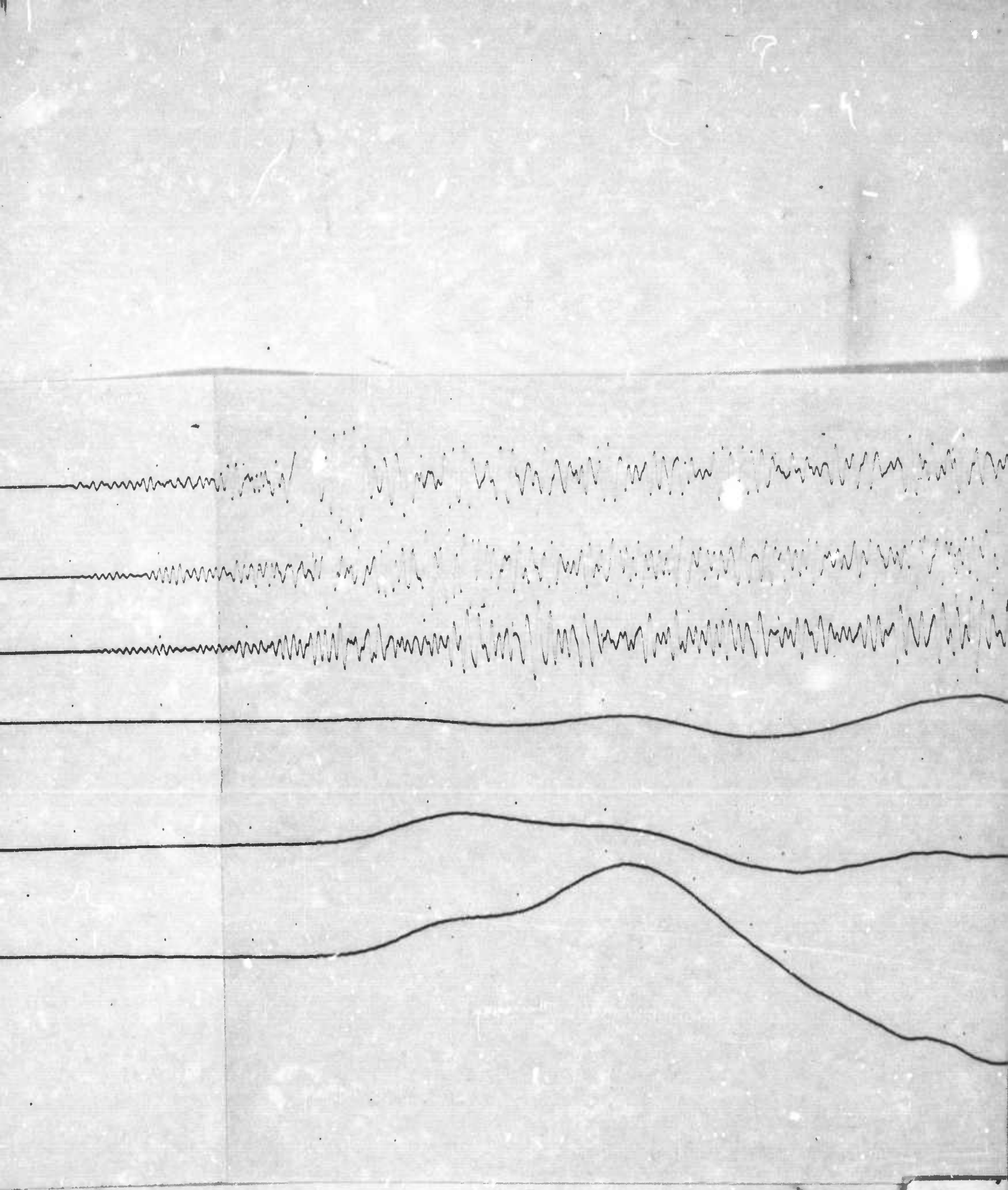
MO-ID

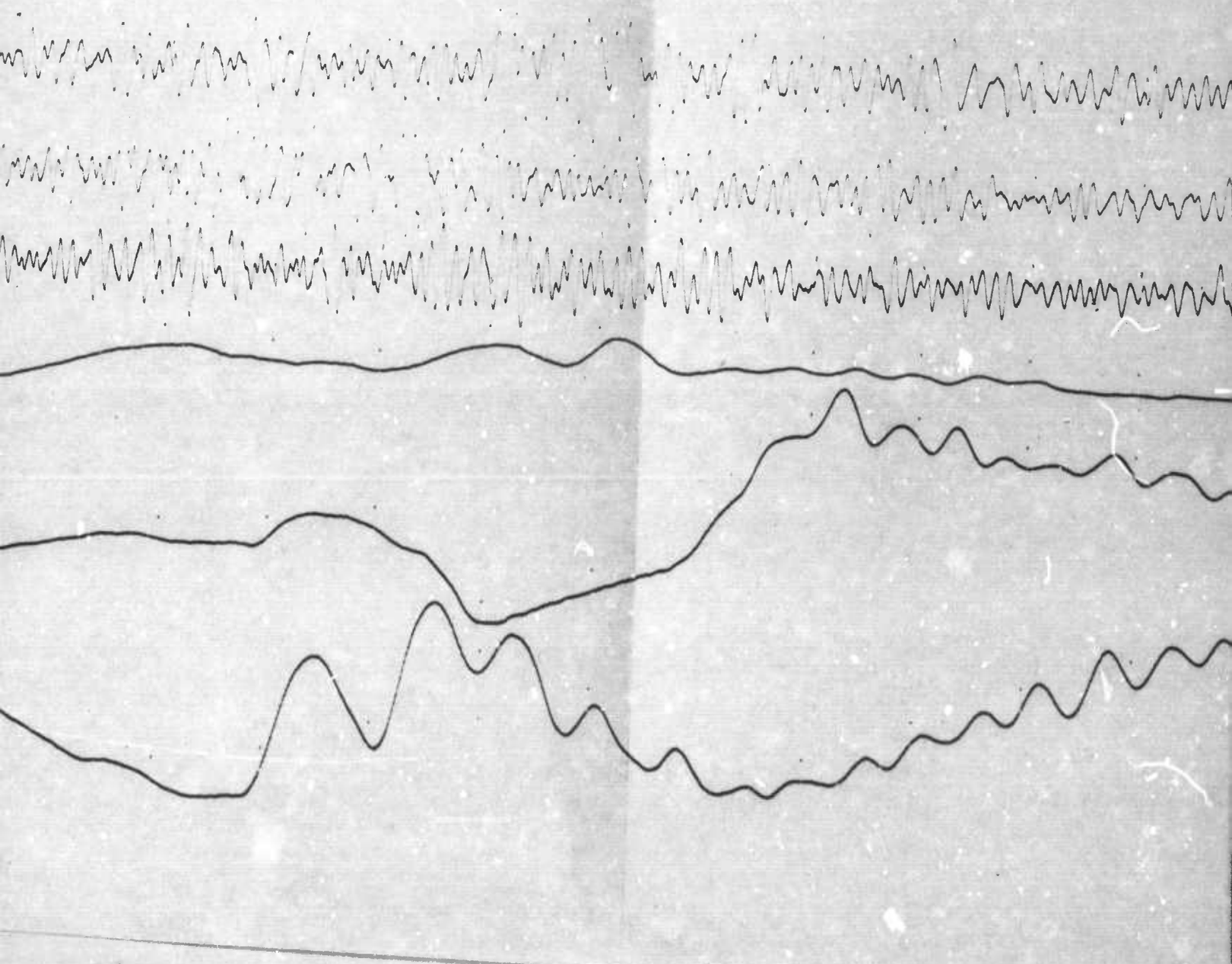
MOUNTAIN HOME, IDAHO

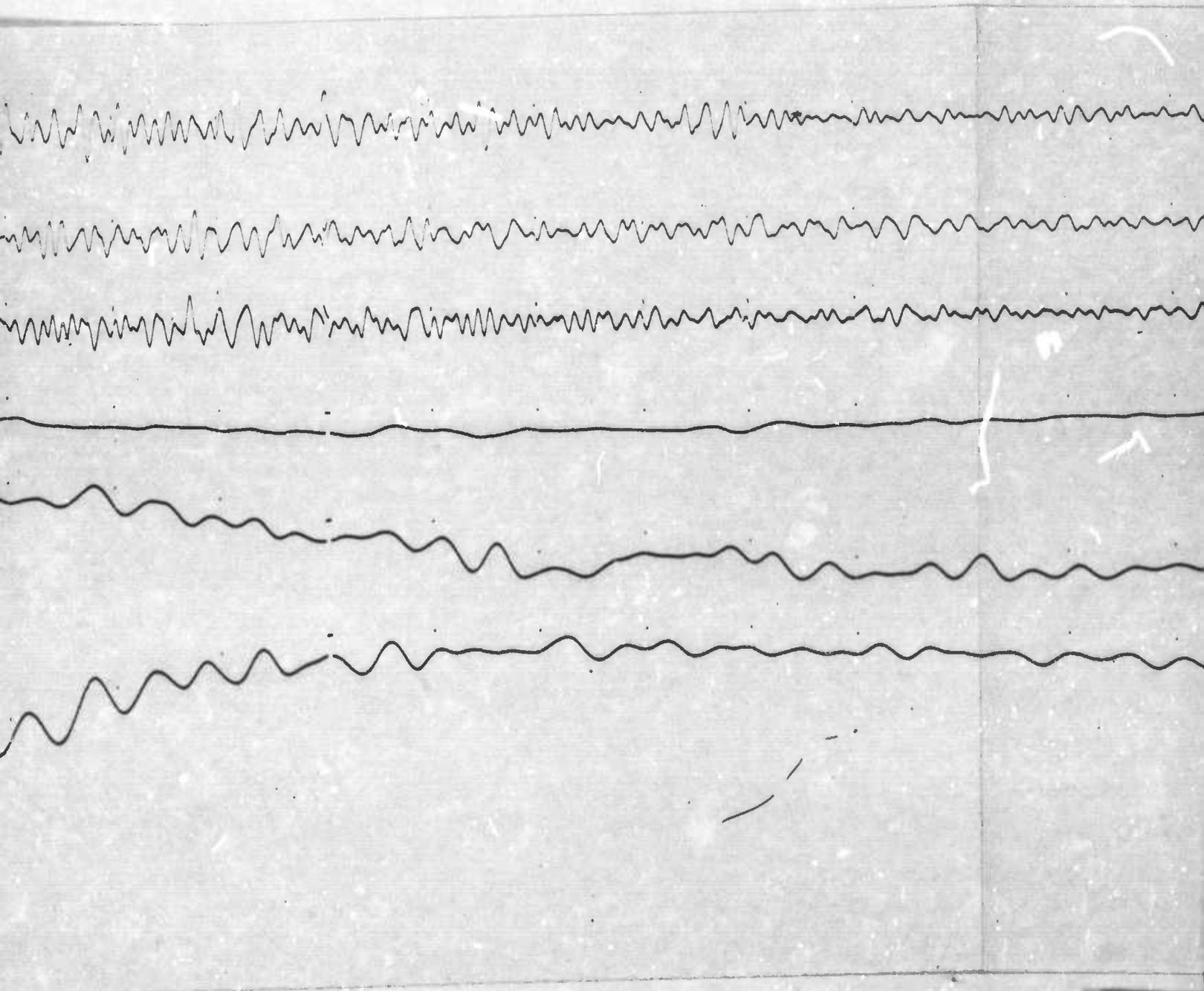
20 DECEMBER 1966

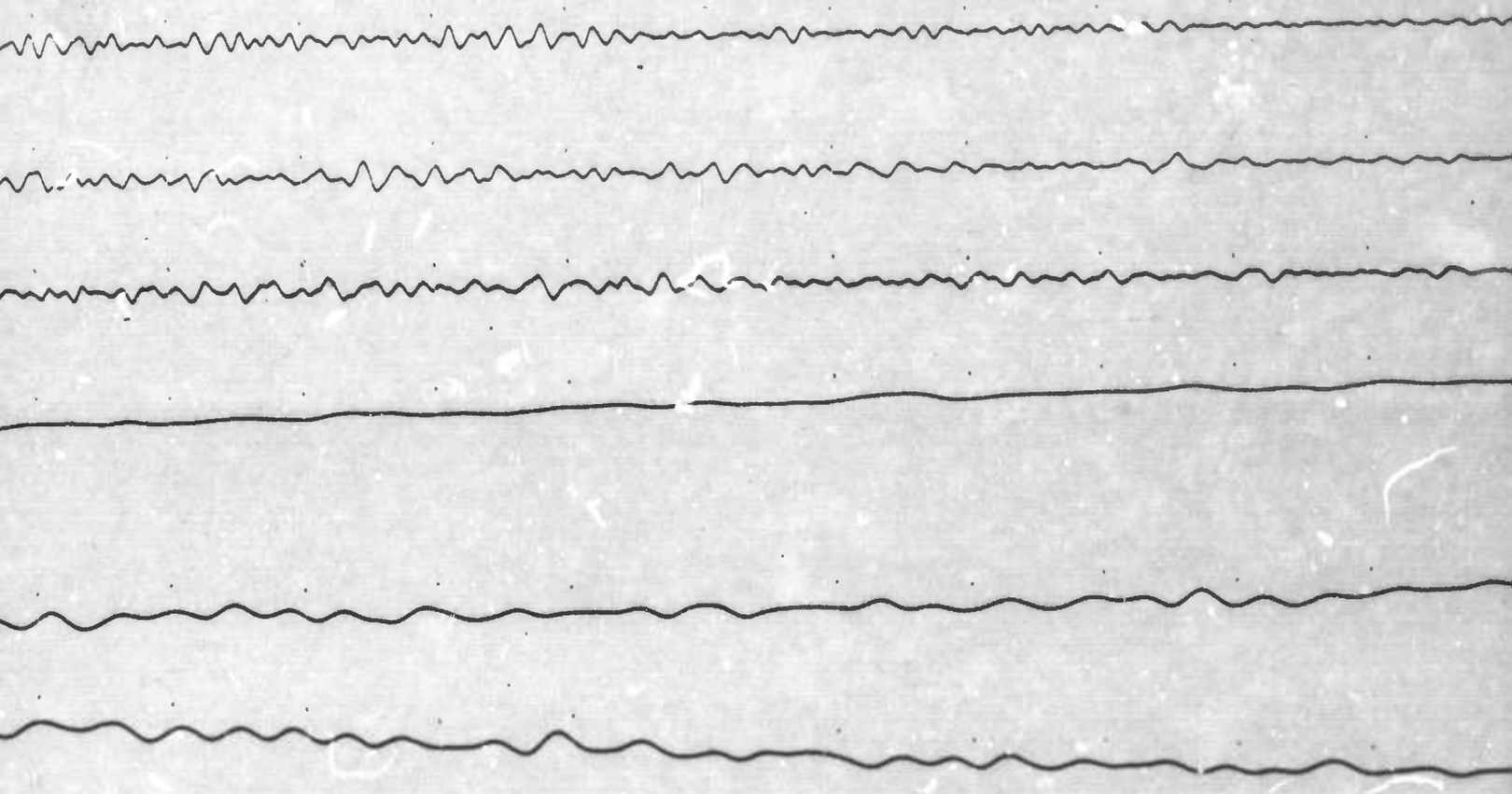
Δ = 641 k.m.

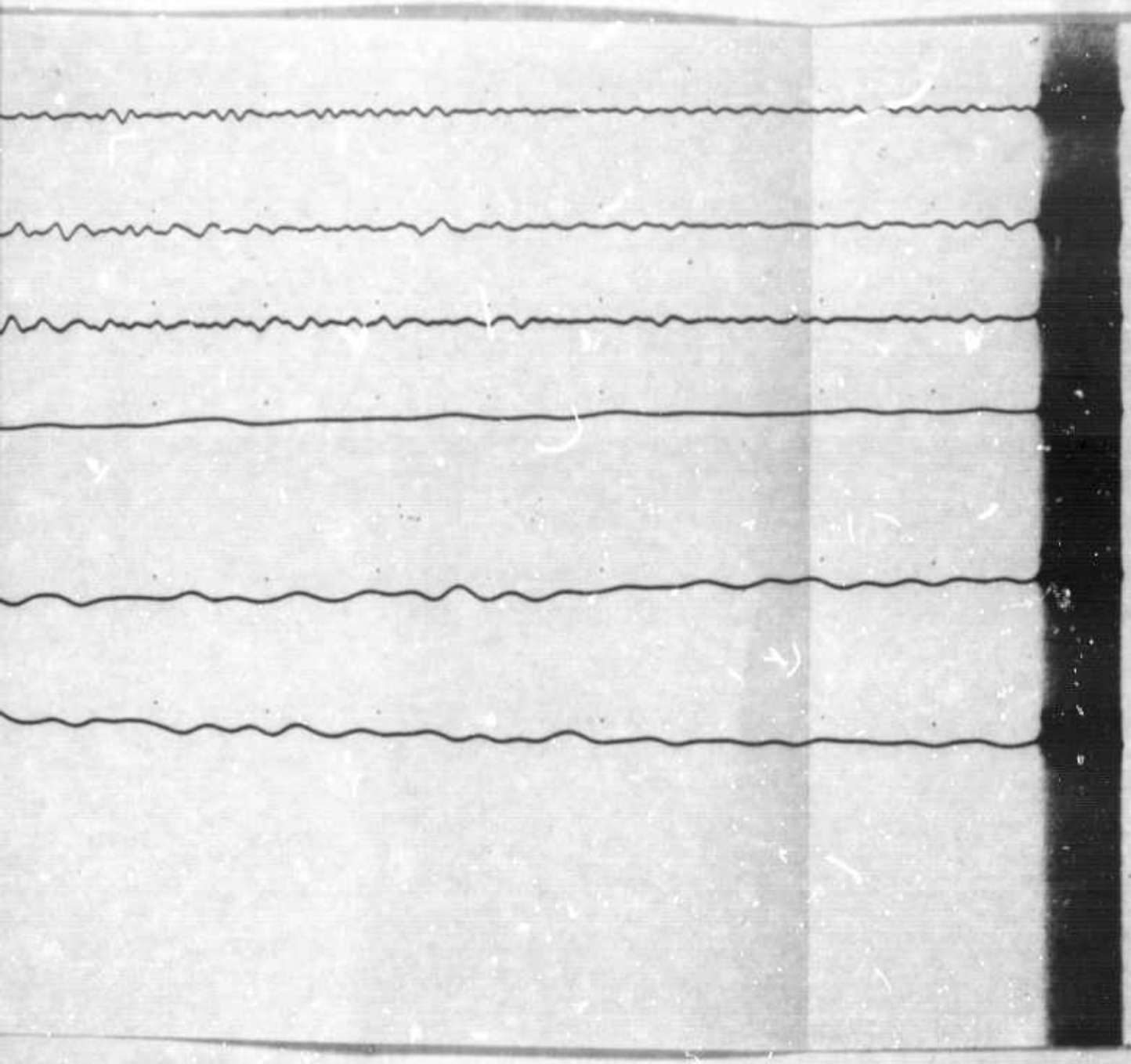












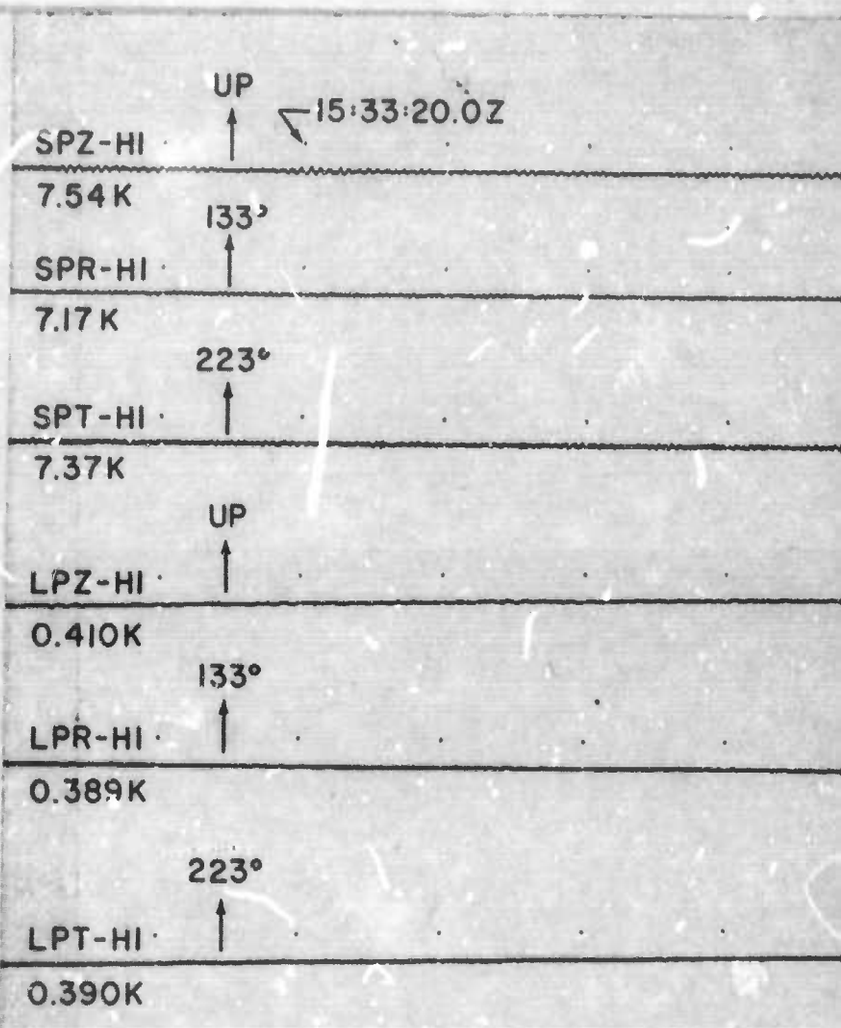
GREELEY

KC-MO

KANSAS CITY, MISSOURI

20 DECEMBER 1966

Δ = 1910 km.



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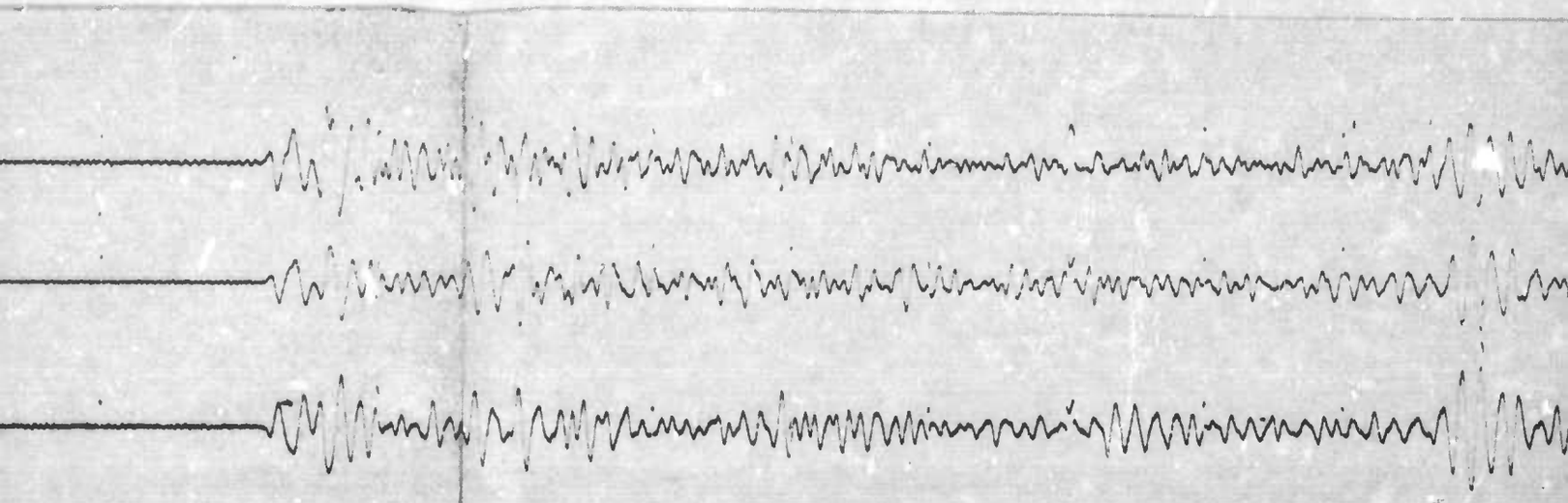

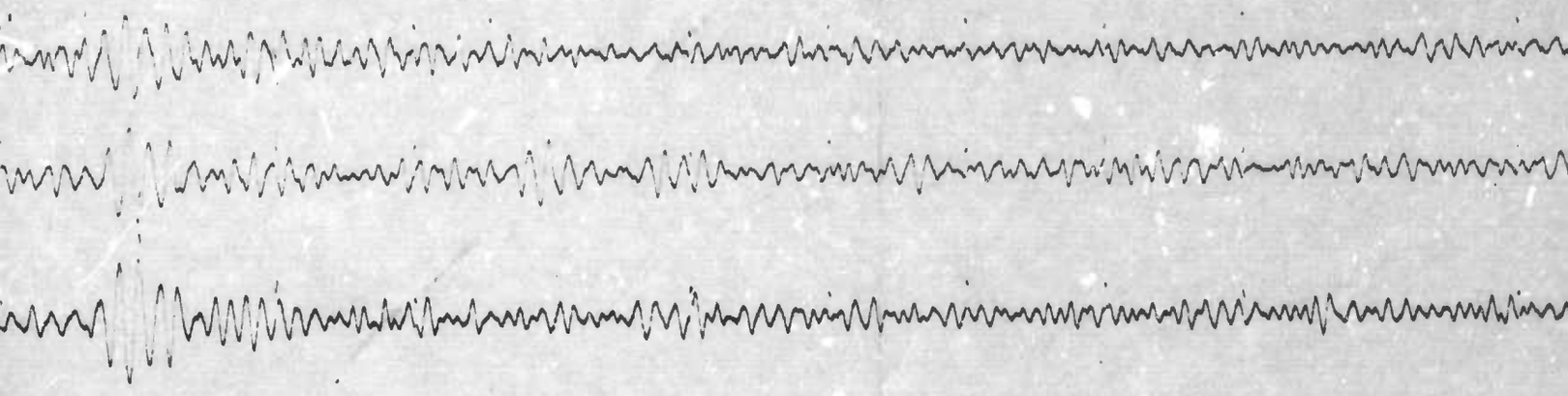

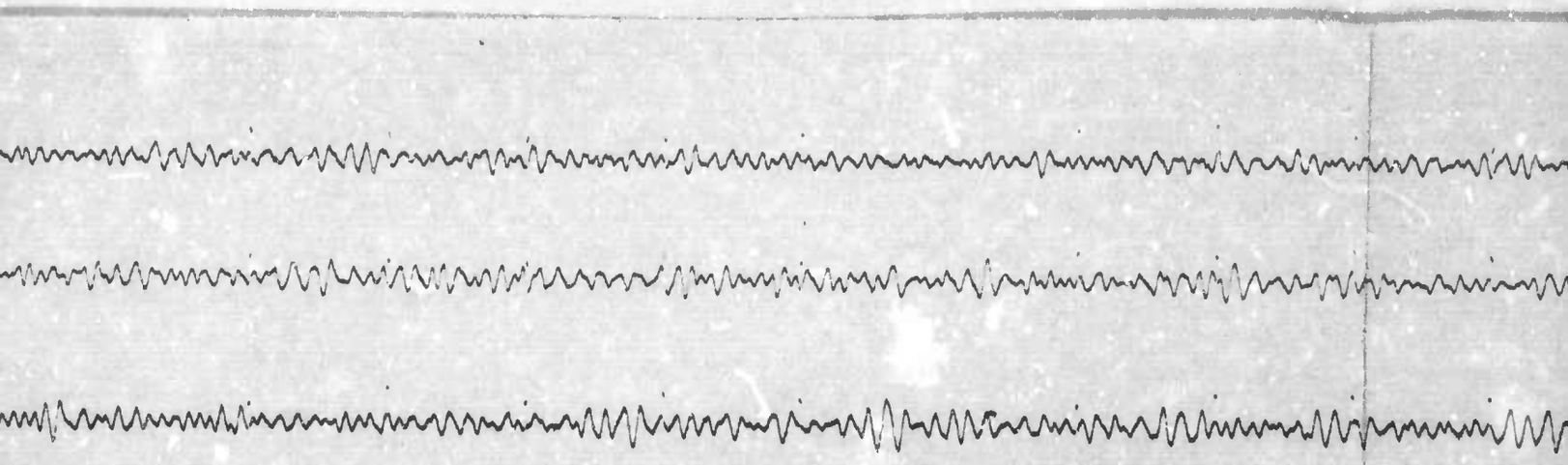

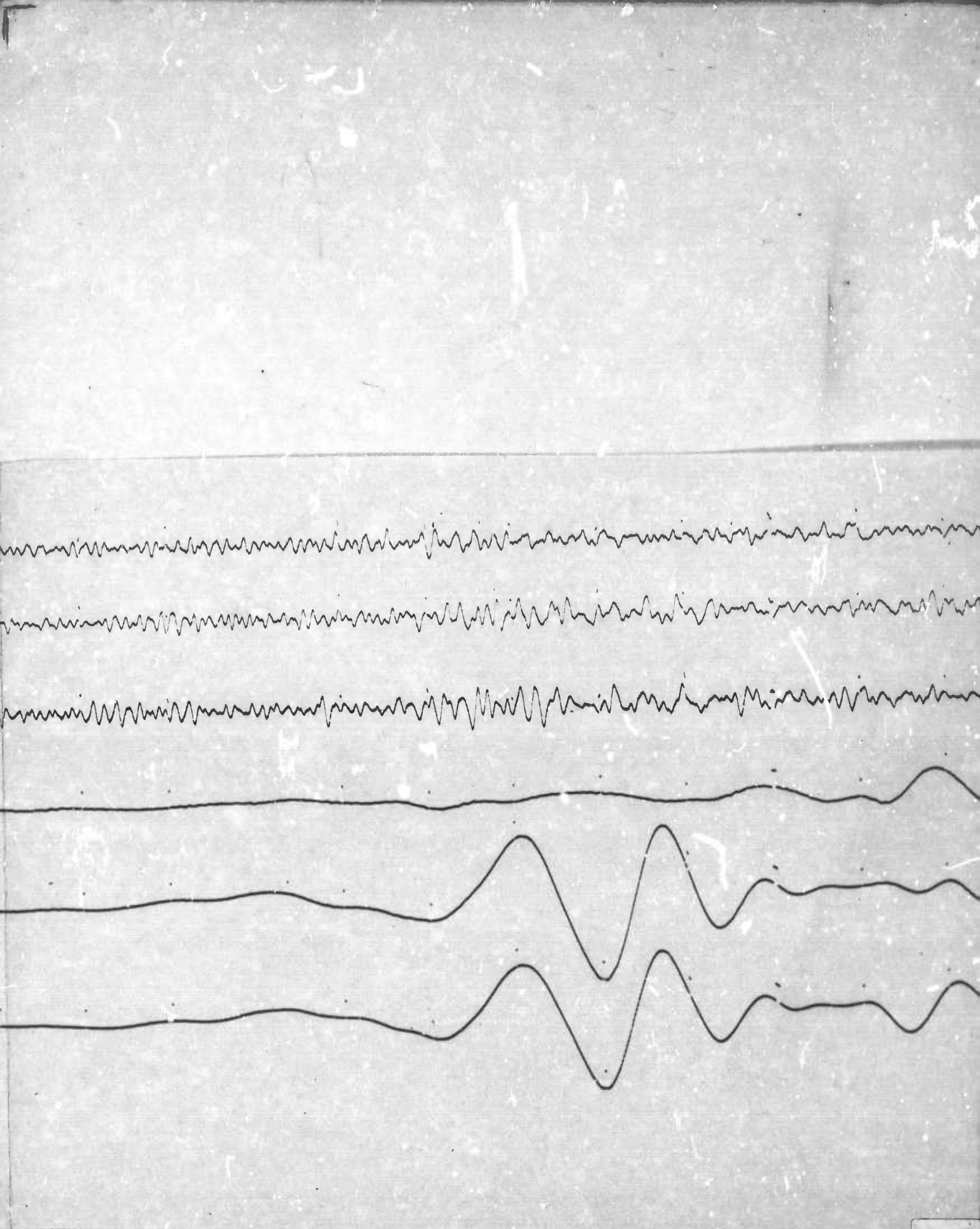

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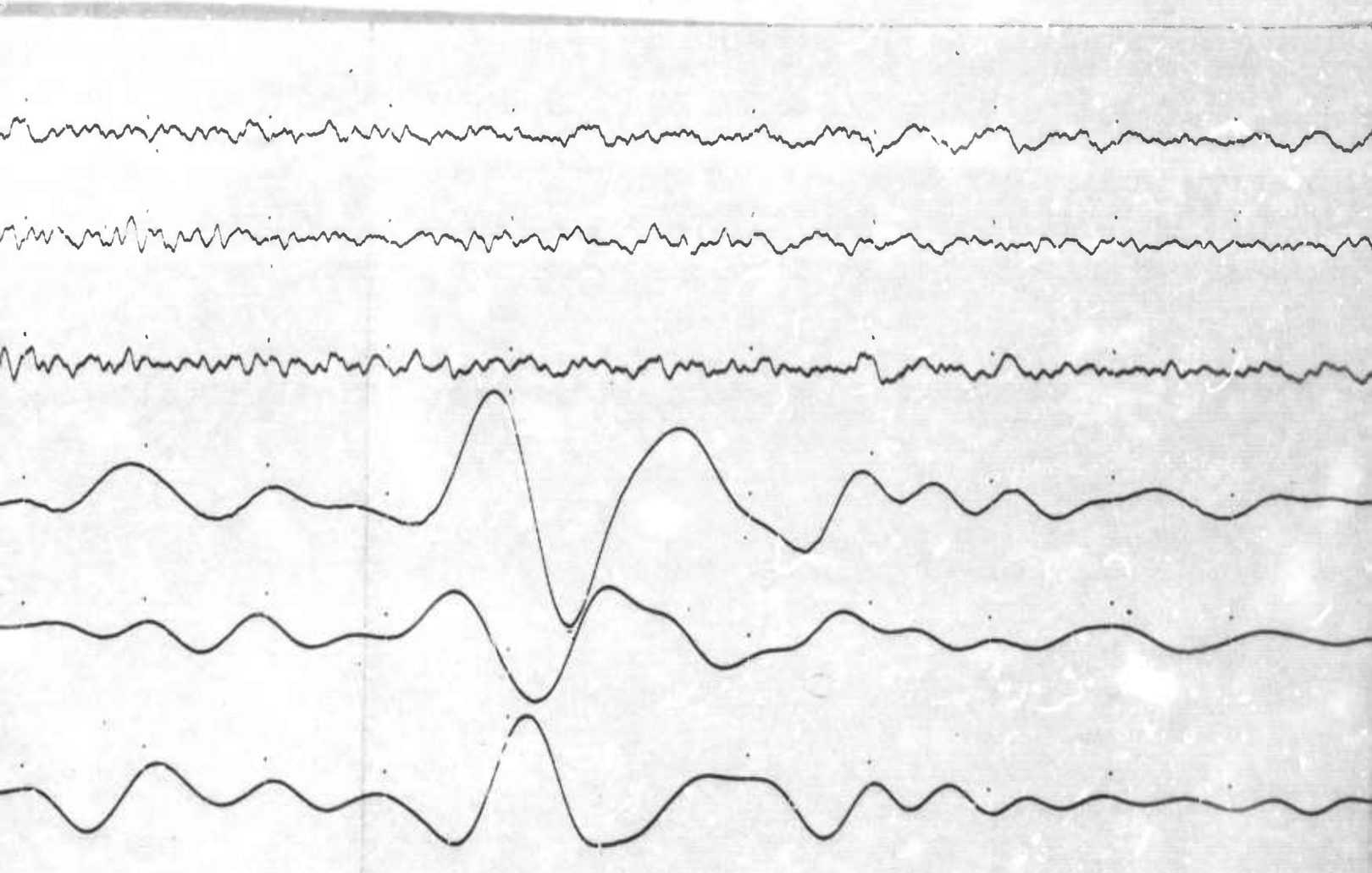

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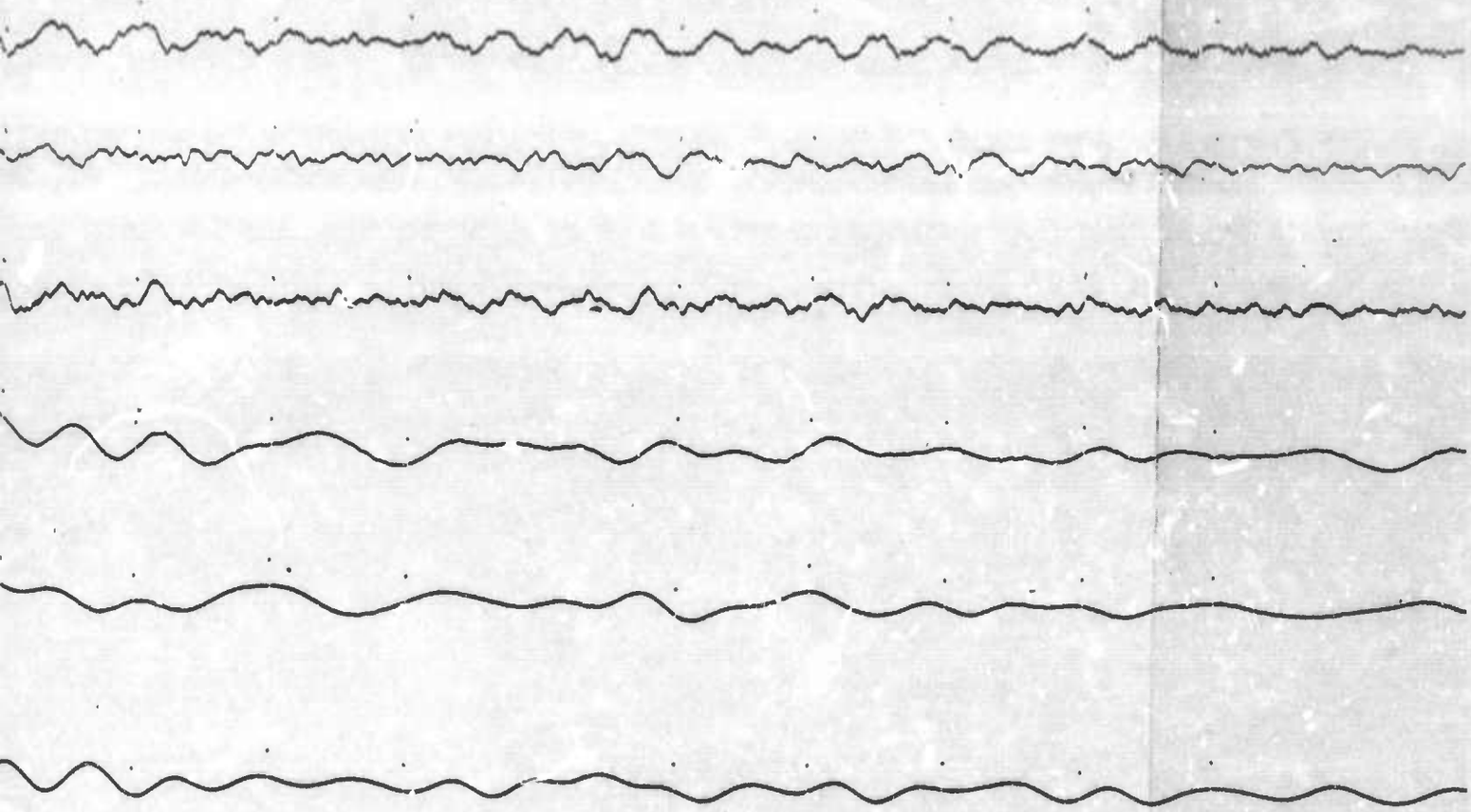


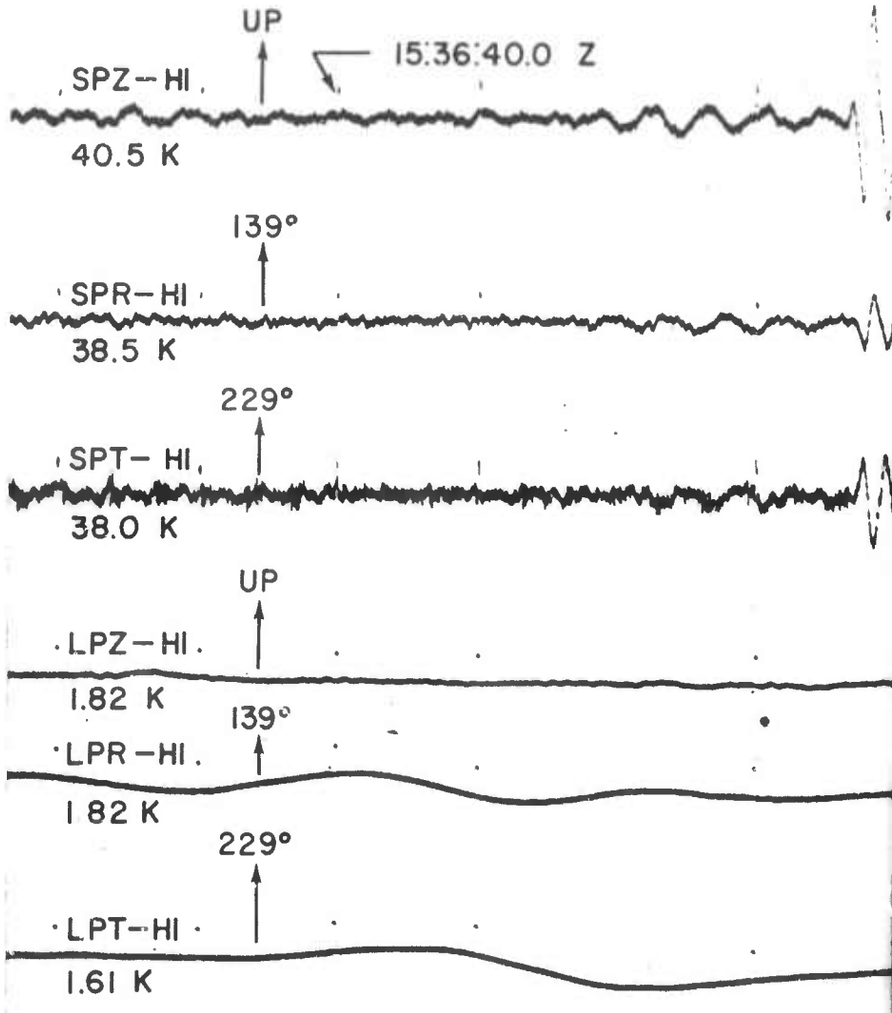
GREELEY

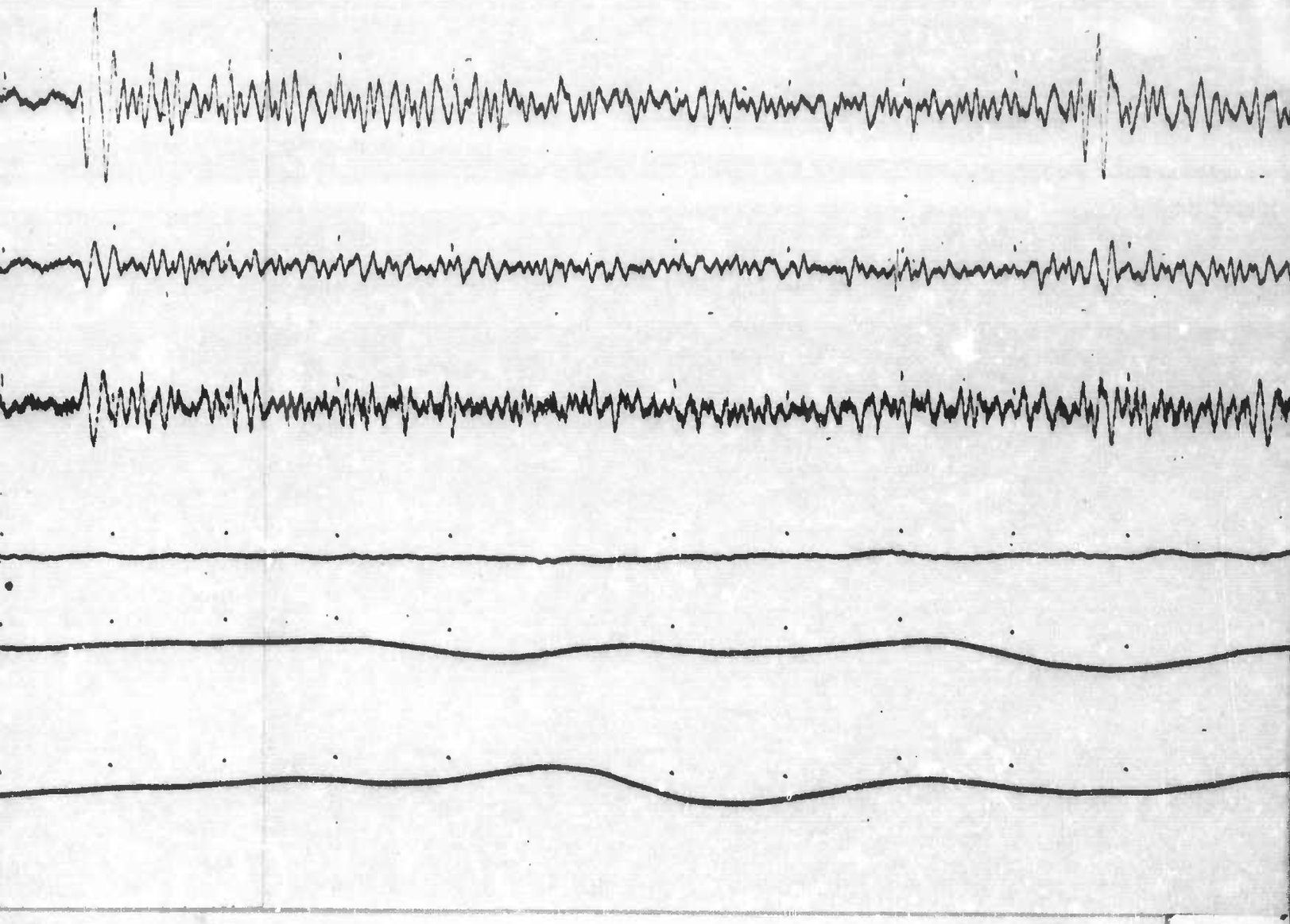
SV3QB

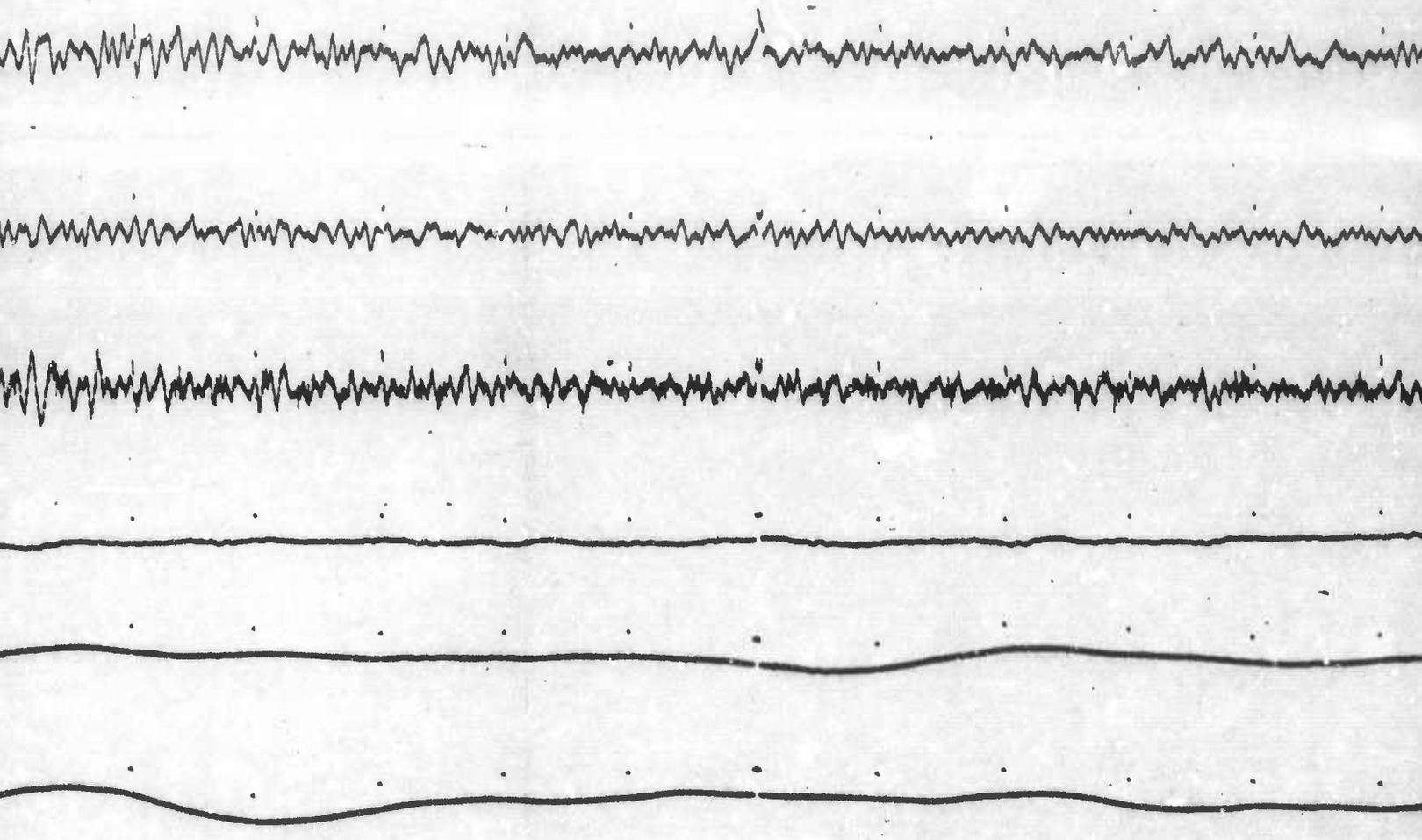
SCHEFFERVILLE, QUEBEC

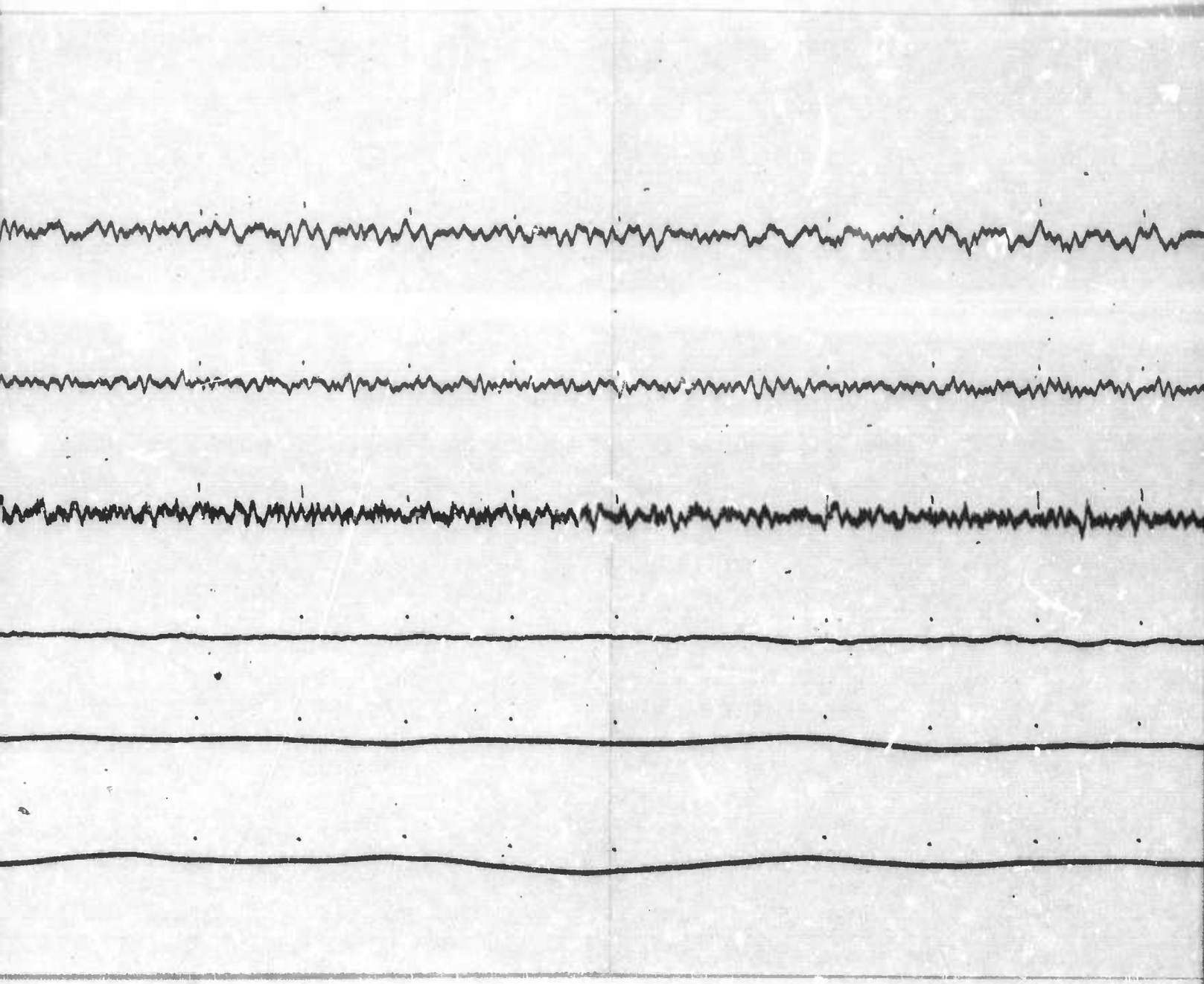
20 DECEMBER 1966

Δ = 4195 km

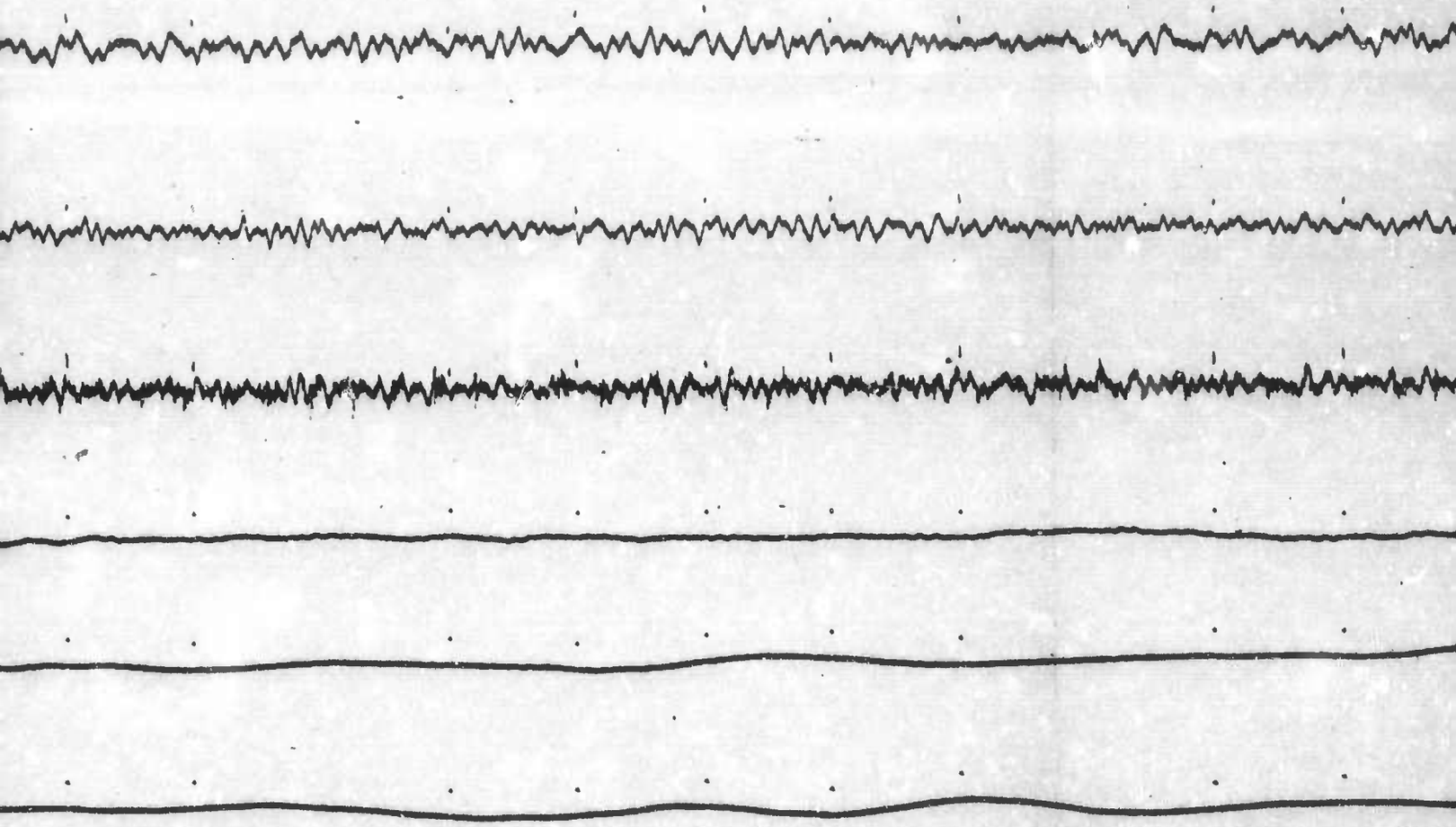


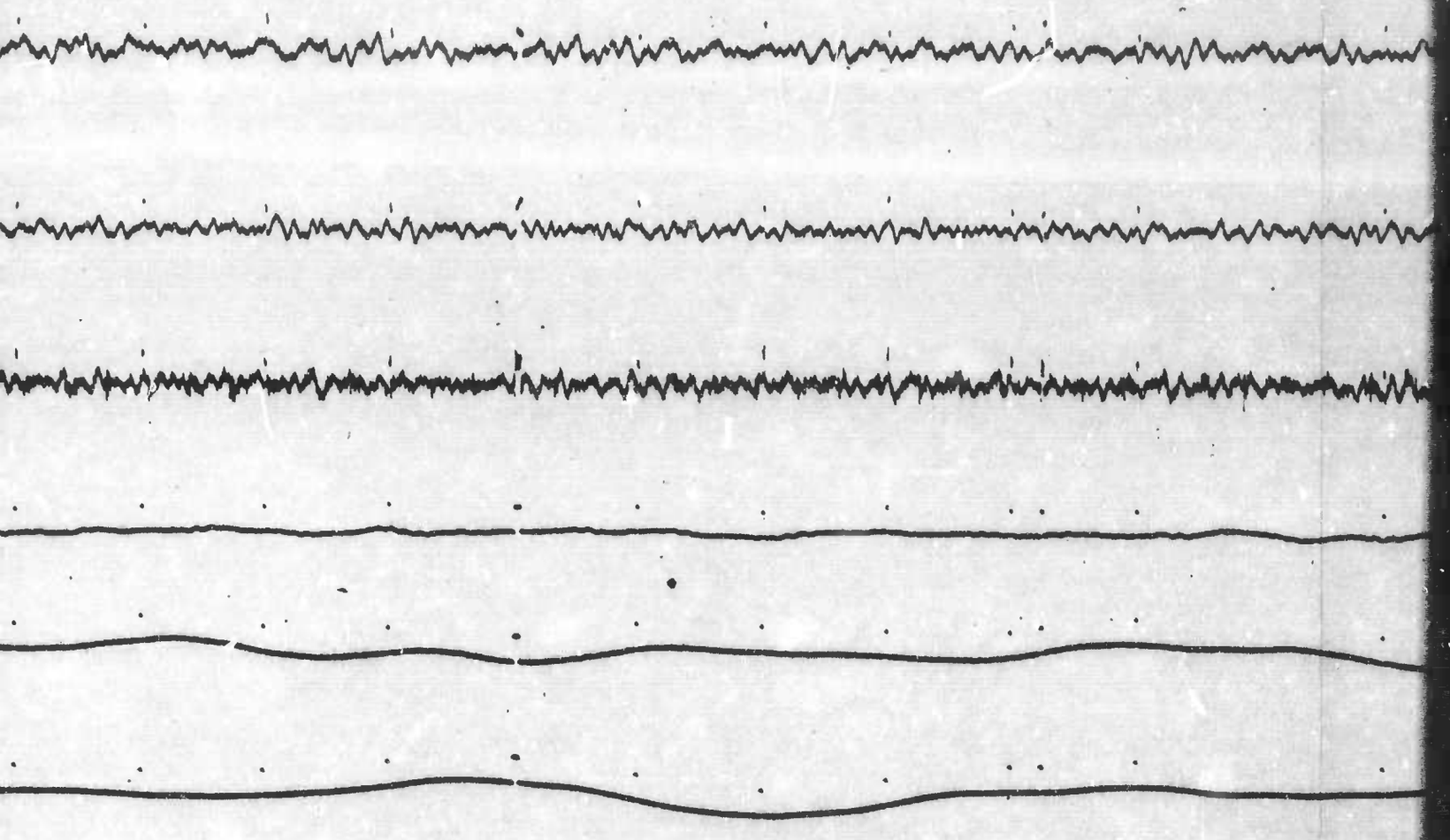


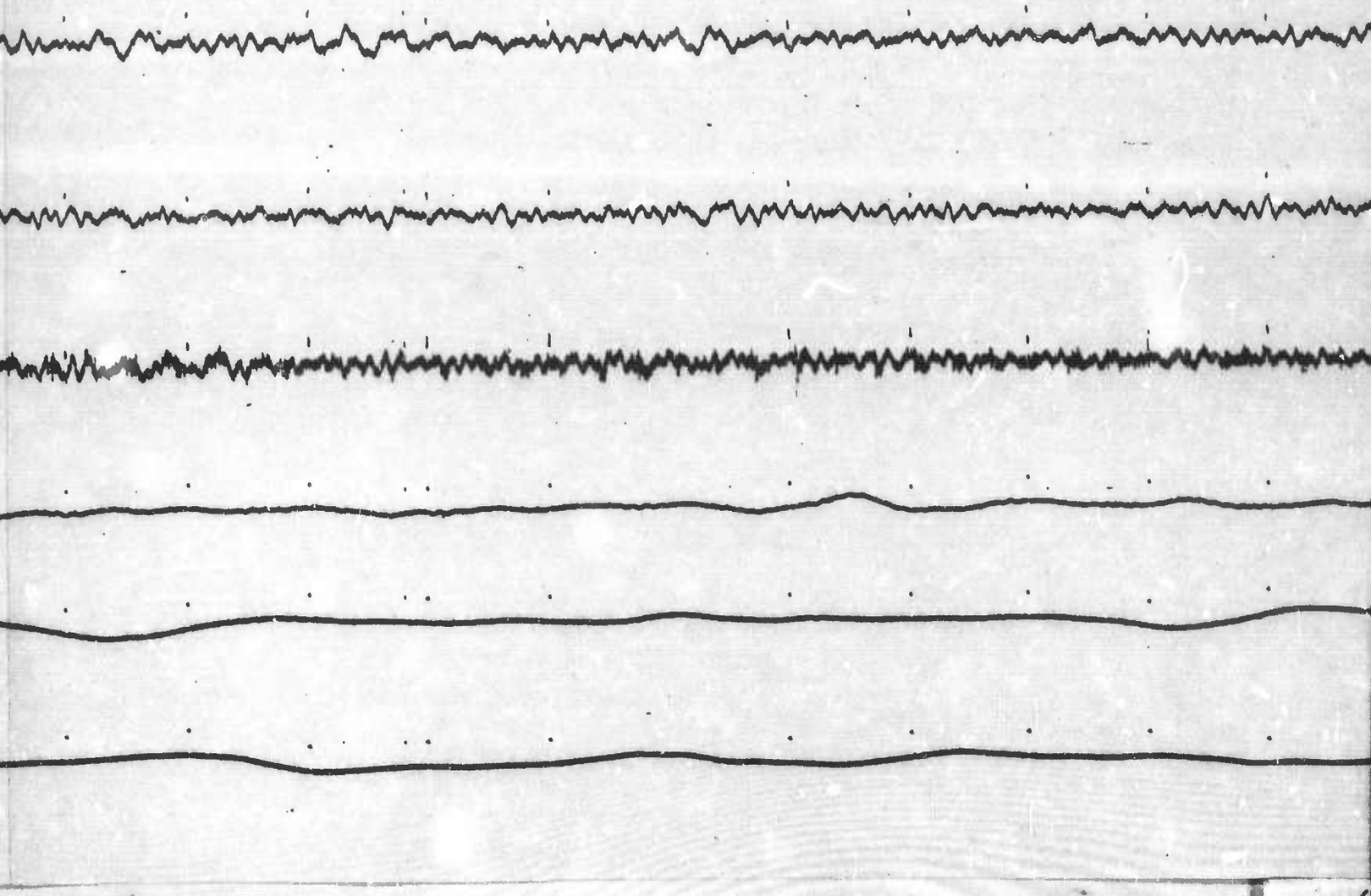


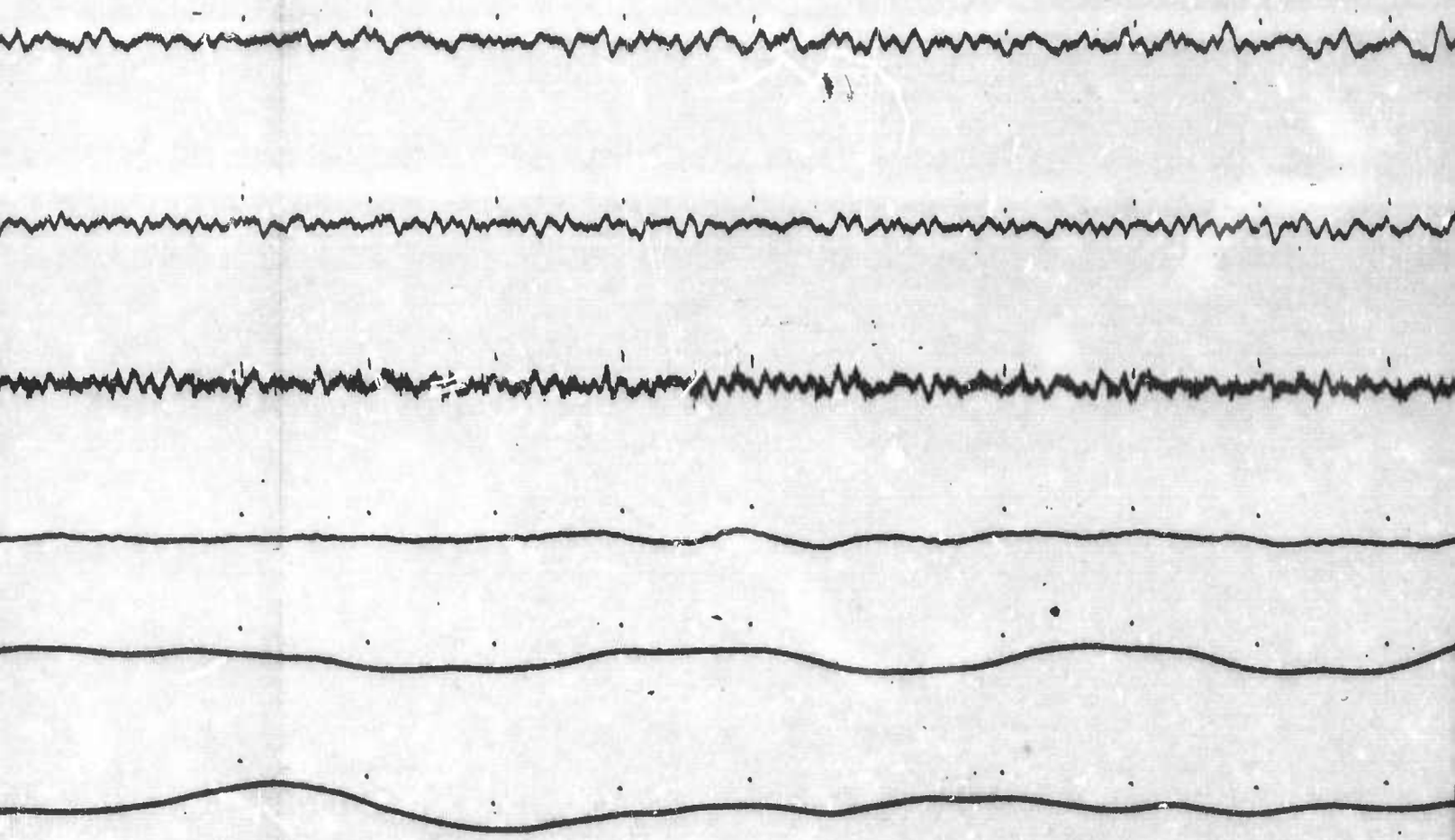


4









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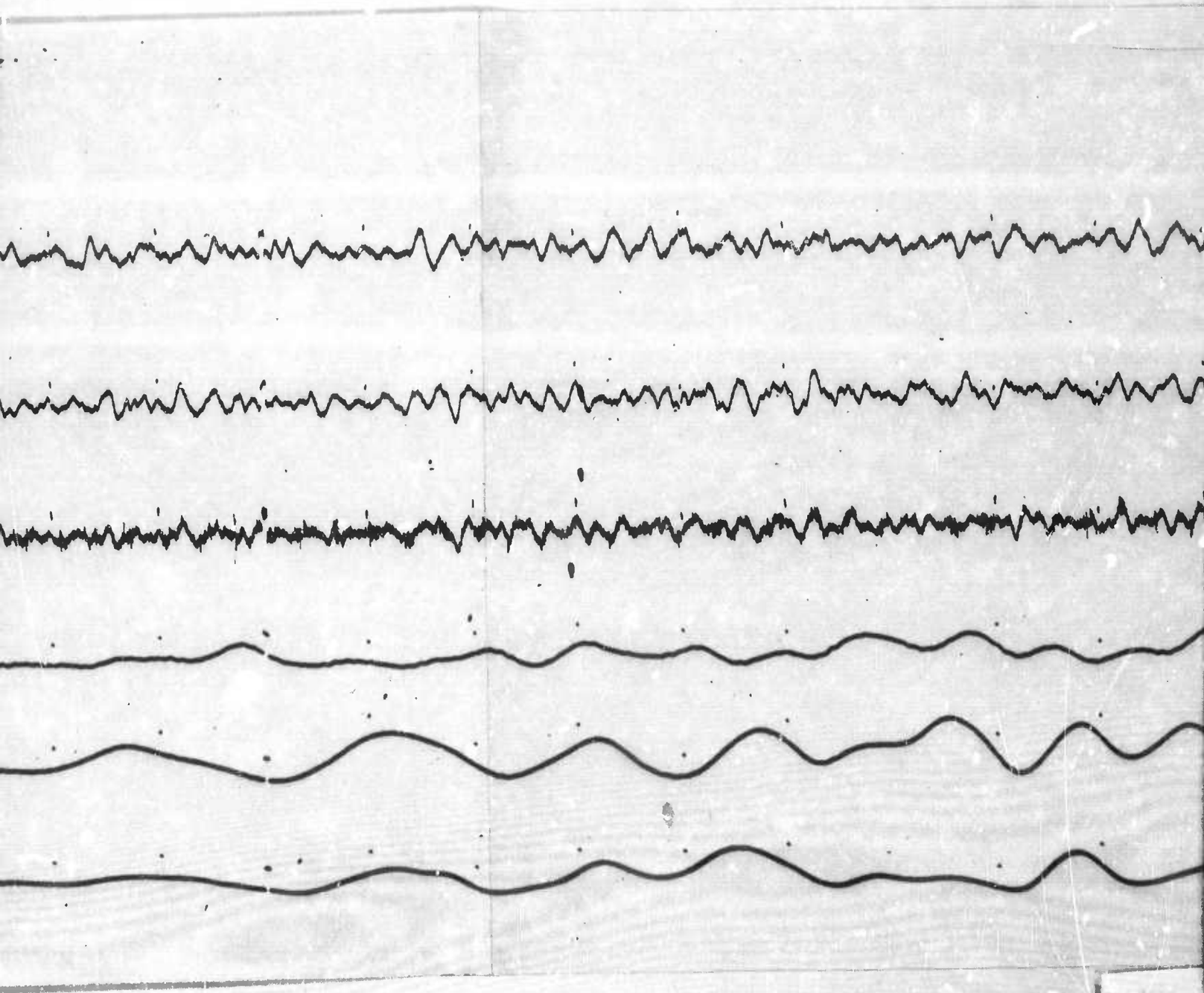

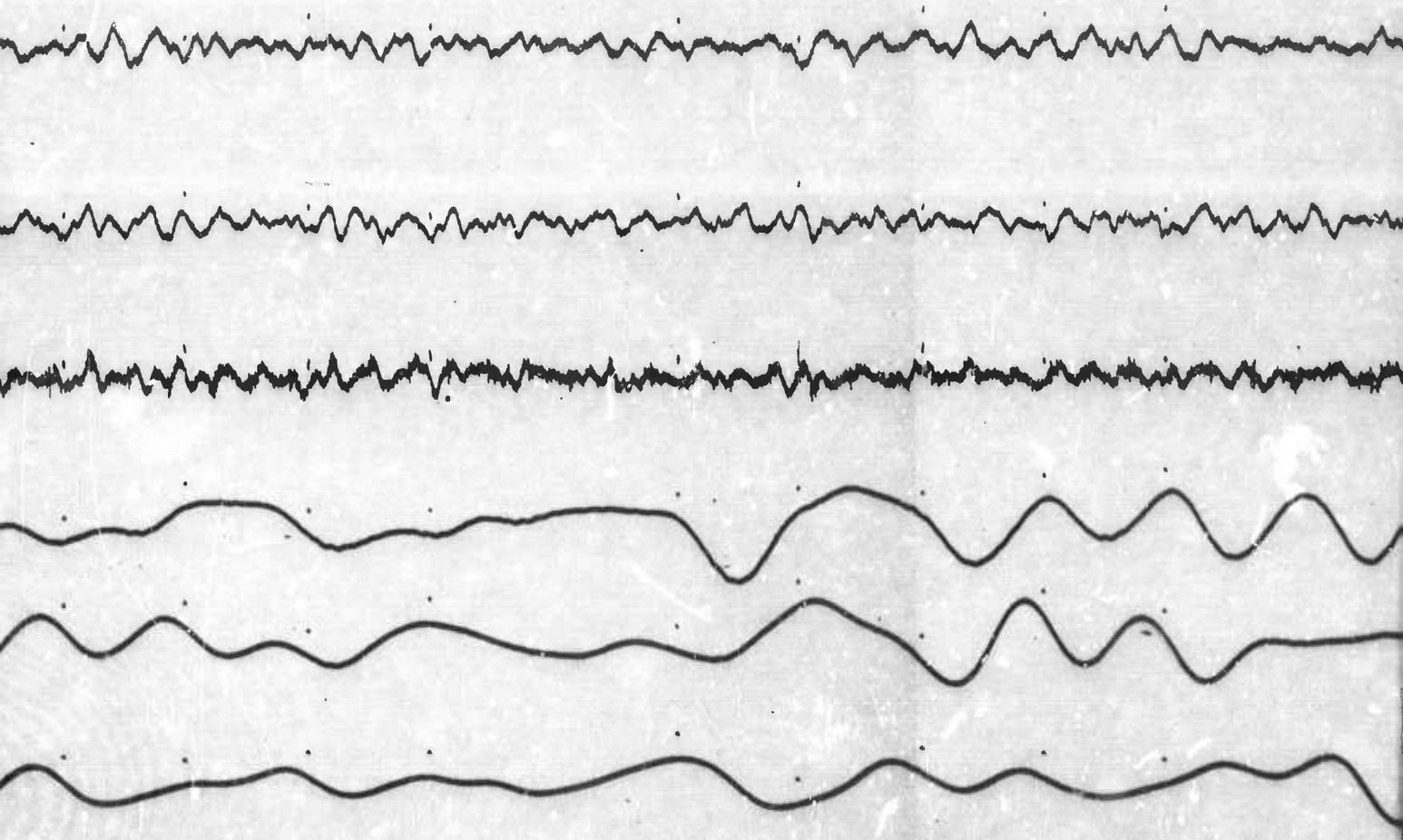

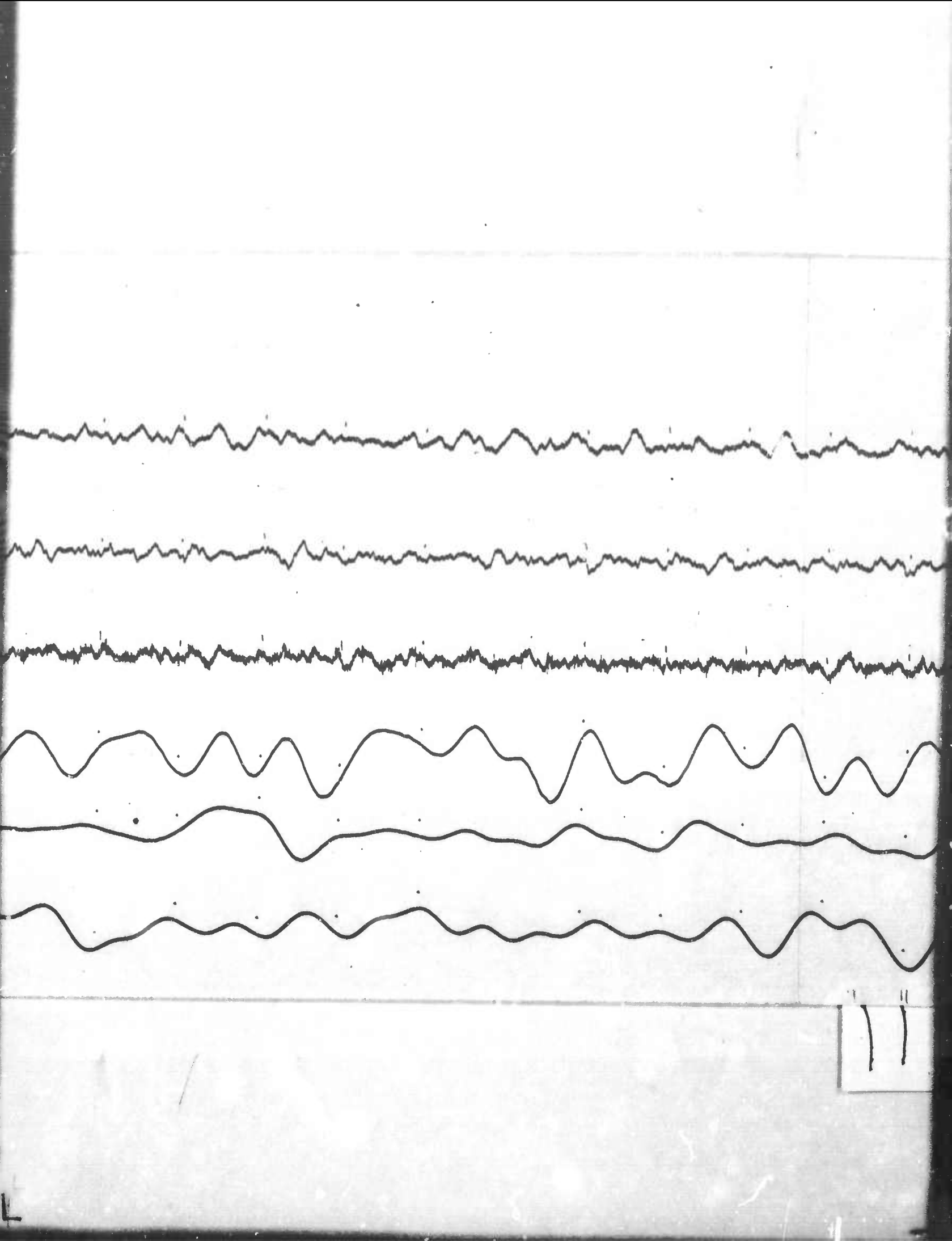

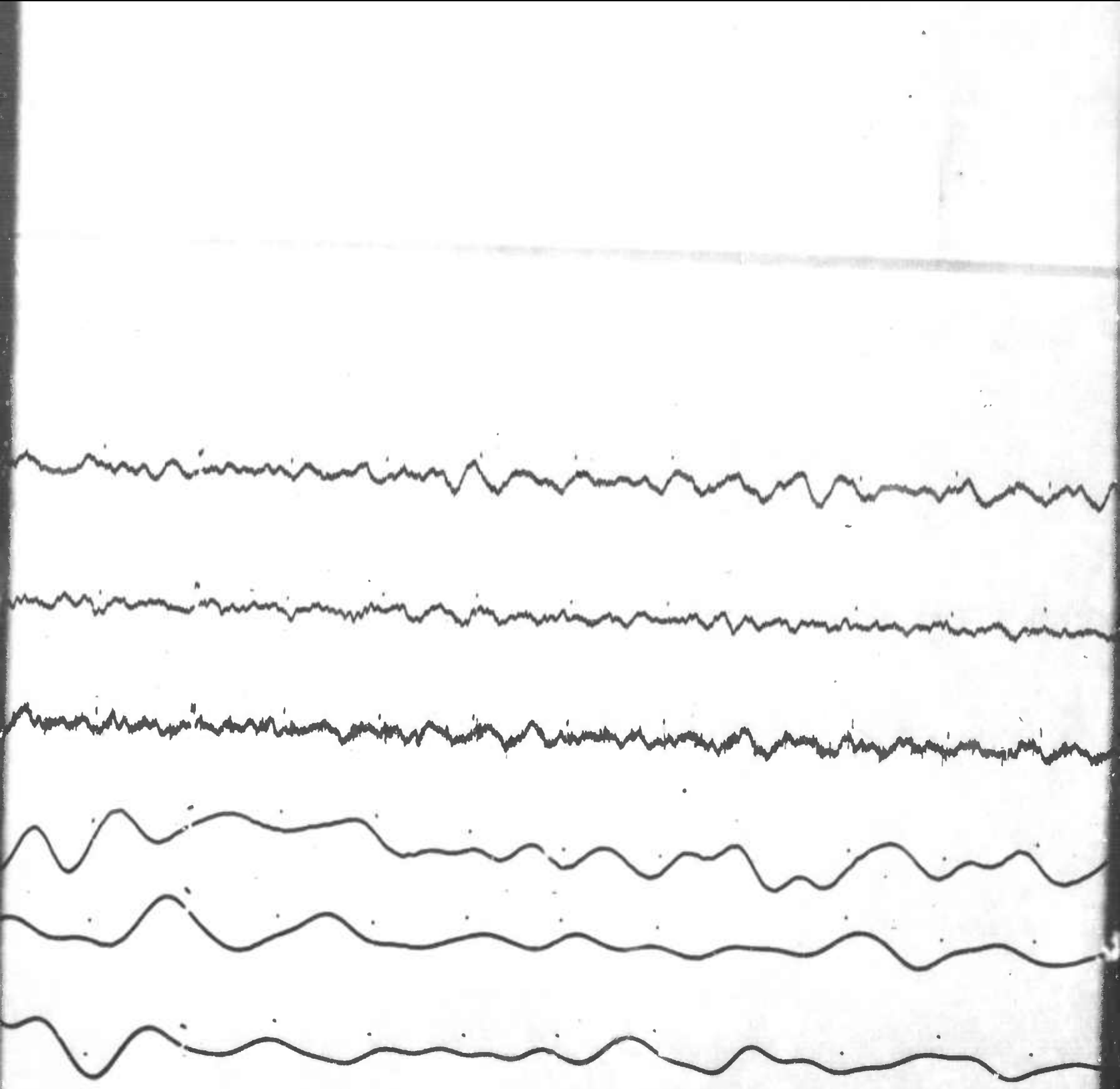

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