THE REGISTRATION OF EARTHQUAKES AT THE BERKELEY STATION

AND

AT THE LICK OBSERVATORY STATION

FROM

October 1, 1924, to March 31, 1925

BY

PERRY BYERLY

AND

GEORGE D. MITCHELL

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CONTENTS

Symbols and Notations

1. *Character of the Earthquake—*

I. Perceptible. II. Moderately strong. III. Strong.

d (terrae motus domesticus)	Local shock (origin less than 100 kilometers distant).
v (terrae motus vicinus)	Near shock (origin from 100 to 1,000 kilometers distant).
r (terrae motus remotus)	Distant shock (origin from 1,000 to 5,000 kilometers distant).
u (terrae motus ultimus)	Very distant shock or teleseism (origin more than 5,000 kilometers distant).

2. *Phases of the Seismogram—*

P (undae primae)	Normal first phase, or first preliminary tremors (longitudinal).
P′	First preliminary tremors which have penetrated the core of the earth.
PR_n	Waves n times reflected at the earth's surface.
S (undae secundae)	Second phase, or second preliminary tremors (transverse).
SR_n	Waves n times reflected at the earth's surface.
PS	Waves changed from longitudinal to transverse oscillation or vice versa through reflection at the earth's surface.
PPS	Waves twice reflected at the earth's surface, having been longitudinal on two branches of the path and transverse on one branch.

In general a bar over two letters denoting types of waves indicates refraction. The subscript $_c$ denotes the boundary at about 2900 km. depth between the metallic core and the middle shell which surrounds it. Thus:

$\overline{S_cP_cS}$	Waves which have penetrated the core, having been transverse before entering and after leaving the core, and longitudinal within the core.
$\overline{P_cP_c}$ $\overline{P_cP_c}$	Waves refracted at the core boundary into the core, reflected once at this boundary while within the core and again refracted out of the core, having remained longitudinal on all branches of the path.
L (undae longae)	Long waves at the beginning of the surface phase.
M (undae maximae)	Shorter and more regular waves of large amplitude in the surface phase.
M_n	Greatest motion in the surface phase.
C (coda)	Tail or end portion.
F (finis)	End of discernible movement.

For local earthquakes a special notation is used:

$\bar{P}$	The longitudinal wave which has traveled its whole path in the surface layer or crust of the earth.
$\bar{S}$	The transverse wave which has traveled its whole path in the surface layer of the earth.

In general R_1 denotes reflection once at the lower (inferior) surface of the earth's crust. R_{i2} denotes reflection twice at this surface. R_s indicates reflection at the upper (superior) surface of the crust, i.e., the surface of the earth. Thus, e.g.:

$R_{i2}\bar{P}_2\bar{S}_2$	A wave in the earth's crust which has been reflected twice at the lower surface, having been longitudinal on two branches of its path and transverse on two branches.

3. *Nature of the Motion—*

i (impetus)	Sudden beginning of the motion.
e (emersio)	Gradual beginning of the motion.
T (period)	Time of one complete oscillation.
A	Amplitude of the earth motion, measured from the median line in microns (μ=1/1000m.), + toward the north, east, or zenith, − toward the south, west, or nadir.
A_E	E–W component of A.
A_N	N–S component of A.
A_Z	Vertical component of A.

4. *Time—*

O (origin)	Time of shock at point of origin.

THE BERKELEY STATION

CONSTANTS

Latitude and longitude of the center of the seismographic room:

φ=37° 52′ 15″.9 N. Lat.

λ=122° 15′ 36″.6 W. from Greenwich.

Time. All determinations are reduced to Greenwich mean civil time.

Altitude, 85.4 meters (280) feet) above mean sea level.

Constants of the Seismographs

Date	Apparatus	Component	V	T_o	ϵ	$\frac{r}{T_o^2}$
Dec. 29	Bosch-Omori	E	42	12.8	5.7	0.0029
		N	33	12.6	4.7	0.0040
	Wiechert	changed		13.1	4.3	0.0033
		Z	44	5.4	5.7	0.0023
Mar. 24	Bosch-Omori	E	38	13.1	4.4	0.0026
		N	47	12.7	5.1	0.0031
	Wiechert	Z	42	5.4	5.6	0.0024

BERKELEY STATION

No	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude			Remarks
						A_E	A_N	A_Z	
	1924			h m s	s	μ	μ	μ	
1	Oct. 14	Iu	ePz	5 11 09					
			eL_{ENZ}	5 35 50					
			F	5 50±					
2	Oct. 17	I	i_Z	4 32					May not be seismic.
			i_N	4 40					
3	Oct. 20	IIv	iP_Z	5 22 34					Rarefaction.
			eP_E	5 22 35					
			$i\overline{P}_{NZ}$	5 22 43					
			i_E	5 22 47					
			i_N	5 22 49					
			i_Z	5 23 00					
			$\overline{S}_{ENZ}$?	5 23 20					
			$L?_{EN}$	5 24 21					
			L_Z	5 24 27					
			F	5 39±					
4	Oct. 21	IIu	iP_{ENZ}	20 01 45					Condensation.
			S_{ENZ}	20 08 56					
			L_{ENZ}	20 16 51					
			M_E	20 18 15					
			F	21 14±					
5	Nov. 4	Iu	i_Z	0 55 16	<0.5			7	Four little after-shocks within the next four minutes. Was not felt.
			F	0 55 17					
6	Nov. 13	Iv	$e\overline{P}_{EN}$?	6 23 13					Felt from Berkeley to Salinas.
			$e\overline{P}_Z$?	6 23 14					
			$i\overline{P}_N$?	6 23 15					
			$i\overline{P}_Z$?	6 23 16					
			i_{NZ}	6 23 19					
			iS_{NZ}?	6 23 27					
			iS_E	6 23 28					
			i_Z	6 23 29					
			i_N	6 23 30					
			$iL?_{ENZ}$	6 23 31	2	−11	−19		
			i_N	6 23 32	2		+13		
			i_{EZ}	6 23 34	2	+16			
			i_E	6 23 38	2	+11			
			M_{NZ}	6 23 46	3		−22		
			M_E	6 23 47	10	−12			
			M_{EN}	6 23 52	10	+16	+23		
			F	6 28±					

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude			Remarks
						A_E	A_N	A_Z	
	1924			h m s	s	μ	μ	μ	
7	Nov. 13	Iu	eP_Z	8 44 27					△=8460 km.
			eP_N	8 44 49					
			eS_Z	8 53 58					
			eS_E	8 54 55					
			eL_E	9 08 57					
			eL_N	9 09 09					
			eL_Z	9 13 33					
			eM_E?	9 14 49					
			F	9 57±					
8	Dec. 28	Iv	$e\overline{P}_N$	4 21 09					Felt in Santa Clara.
			$e\overline{P}_Z$	4 21 10					
			$e\overline{P}_E$	4 21 12					
			$i\overline{S}_{ENZ}$	4 21 27					
			F	4 25±					
9	Dec. 28-29	IIu	iP_Z	23 05 43					△=7360 km. Japan.
			iP_N	23 05 52					
			iP_E	23 05 57					
			PR_{1E}	23 08 35					
			eS_{ENZ}	23 14 34					
			eL_E	23 25 02					
			eL_N	23 25 12					
			eL_Z	23 25 22					
			F	1 06±					
10	Dec. 30	Id	$i\overline{P}_{NZ}$	7 27 20					Felt in San Francisco.
			$i\overline{P}_E$	7 27 21					
			i_N	7 27 23					
			i_N	7 27 27					
			$i\overline{S}_{ENZ}$	7 27 28					
			F	7 29±					
	1925								
11	Jan. 5	I	eL_{EN}	21 49 50					The earlier phases are lost in microseisms. *May be beginning of a second shock.
			eL_Z	21 53 10					
			*i_{ENZ}	22 02 06					
			eL_E	22 06 50					
			eL_N	22 10 08					
			eL_Z	22 11 10					
			F	22 18±					
12	Jan. 18	IIu	iP_{ENZ}	12 15 57					Probably in Kurile Islands.
			PR_{3N}	12 19 55					
			PR_{3E}	12 19 56					
			PR_{3Z}	12 20 05					

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude			Remarks
						A_E	A_N	A_Z	
	1925			h m s	s	μ	μ	μ	
12	Jan. 18 (contd.)	IIu	iS_E	12 24 05					
			iS_{NZ}	12 24 07					
			PS_{EN}	12 24 31					
			PS_Z	12 24 34					
			i_{EN}	12 24 43					
			i_N	12 25 02					
			L_N	12 30 51					
			L_E	12 30 53					
			M_{EZ}	12 32 58					
			F	14 28±					
13	Jan. 26	Iv	eP_Z	5 46 35					Amplitudes very small and phases indistinct.
			eP_E	5 46 36					
			eP_N	5 46 37					
			i_N	5 46 44					
			i_{EZ}	5 46 53					
			i_N	5 46 54					
			i_Z	5 47 13					
			i_N	5 47 23					
			i_E	5 47 24					
			L_N	5 47 35					
			L_E	5 47 36					
			M_N	5 47 51					
			M_E	5 47 54					
			F	5 54±					
14	Jan. 26	I	e_E	19 17 22					
			e_N	19 17 30					
			e_{N1}	19 17 42	8				
			e_{N2}	19 17 50	8				
			F	19 45±					
15	Jan. 28	I	e_{EN}	4 24 50					No record on vertical components.
			e_{N1}	4 24 54	16				
			e_{N2}	4 25 10	16				
			e_{E1}	4 25 24	16				
			e_{E2}	4 25 40	16				
			F	6 15±					
16	Jan. 30	IIu	P_Z	17 00 15	4				
			P_{Z1}	17 00 21	4				
			S_E	17 07 27	6				
			S_{E1}	17 07 39	6				
			e_E	17 09 23					
			eL_E	17 52 15					

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude			Remarks
						A_E	A_N	A_Z	
	1925			h m s	s	μ	μ	μ	
16	Jan. 30 (contd.)	IIu	eL_Z	17 52 15	18				
			eL_N	17 52 33	16				
			L_{N1}	17 52 31	16				
			L_{Z1}	17 52 33	18				
			F	19 21±					
17	Feb. 1	IIu	P_Z	5 33 59	4				
			S_{EN}	5 43 19					
			S_{E1}	5 43 19	6				
			$L?_N$	5 54 13					
			$L?_{N1}$	5 54 23	10				
			$L?_{N2}$	5 54 33	12				
			$L?_E$	5 55 21	20				
			$L?_{E1}$	5 55 41	20				
			eL_Z	5 56 45					
			F	6 50±					
18	Feb. 1	I	e_{EN}	21 00 11					
			e_Z	21 02 11					
			$eL?_E$	21 06 41					
			$L?_{E1}$	21 08 11	12				
			eL_N	21 07 19					
			L_{N1}	21 08 19	10				
			eL_Z	21 08 36					
			F	22 19±					
19	Feb. 2	Iu	P_Z	19 57 28	3				
			P_{Z1}	19 57 31	3				
			S_E	20 06 10					
			S_N	20 06 10	6				
			S_{E1}	20 06 34	20				
			S_{E2}	20 06 54	20				
			e_N	20 20 30	8				
			e_N	20 20 38	8				
			L_E	20 21 46	20				
			L_{E1}	20 22 06	20				
			M_E	20 27 14	8				
			M_{E1}	20 27 22	6				
			M_{E2}	20 27 28	8				
			e_N	20 27 32	8				
			F	21 29±					
20	Feb. 9	I	eL_E	14 50 29	28				
			L_{E1}	14 50 57	28				
			L_N	14 51 01	28				
			M_E	14 52 55	20				

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1925			h m s	s	μ	μ	μ	
20	Feb. 9	I	M_N	14 53 25	18				
			M_{E1}	14 59 01	18				
			M_{N1}	14 59 09	18				
			F	15 19±					
21	Feb. 10	Id	$i\overline{P}_E$	9 05 21	<0.5	+13			△=37 km. Felt strongly in San Mateo and by some in Oakland and San Francisco.
			$i\overline{P}_N$	9 05 21	0.4		+15		
			$i\overline{P}_Z$	9 05 22	<0.5			− 2	
			$i\overline{S}_{EN}$	9 05 26					
			$i\overline{S}_Z$	9 05 27					
			M_E	9 05 27	<0.5	−39			Epicenter in Crystal Springs Lake.
			M_N	9 05 27	<0.5		+42		
			M_Z	9 05 30	<0.5			+ 9	
			F	9 06±					
22	Feb. 23–24	IIr	P_{ENZ}	23 59 37					Epicenter in neighborhood of Kenai Peninsula, Alaska. Earthquake broke Seward - Valdez cable. In Anchorage patients in hospital thrown out of beds. At Moraine the water tanks were broken. Very strong at Fairbanks and Seward.
			P_{Z1}	23 59 39	3				
			P_{Z2}	23 59 42	0.5			10	
			PR_{1EN}	0 00 25					
			PR_{2E}	0 00 37					
			PR_{2N}	0 00 41					
			S_E	0 04 25					
			S_N	0 04 25	10		18		
			S_Z	0 04 28					
			i_E	0 05 39					
			SR_{1E}	0 05 59					
			SR_{3E}	0 06 33					
			L_E	0 07 37	20	74			
			L_Z	0 07 37					
			M_E	0 10 37	12	11			
			F	0 55±					
23	Mar. 1	Ir	P_Z	2 26 42					Felt throughout Eastern States. △=4400 km.
			P_{Z1}	2 26 43	9				
			eP_{EN}	2 26 47					
			$PR?_{2E}$	2 27 23					
			i?	2 31 31					
			S_{EN}	2 32 43	6				
			S_Z	2 32 48					
			$SR?_{2E}$	2 35 37	10				
			$SR?_{2E1}$	2 35 47	10				
			L_Z	2 38 31					
			L_{Z1}	2 38 37	10				
			M_E	2 40 39	8	21			
			F	3 40±					

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1925			h m s	s	μ	μ	μ	
24	Mar. 22	IIu	iP_Z	8 54 38					
			eP_N	8 54 38					
			eP_E	8 54 53					
			eS_N	9 04 37					
			eS_E	9 04 43					
			PS_Z	9 05 18					
			PS_N	9 05 20					
			PS_E	9 05 22					
			i_Z	9 06 20					
			i_E	9 06 22	18	+24			
			i_N	9 06 26	21		+29		
			SR_{3N}	9 14 02					
			i_N	9 17 18					
			i_N	9 18 02	32		+50		
			eL_{EN}	9 21 02					
			eM_N	9 28 02	18		+14		
			eM_E	9 29 46					
			W_{2N}	11 09 02					
			W_{2E}	11 10 20					
			F	11 37±					
25	Mar. 29	Iu	P_{EN}	21 21 32					
			P_Z	21 21 32	4				
			P_{Z1}	21 21 36	4				
			PR_{1Z}	21 21 46					
			PR_{1Z1}	21 23 52	3				
			PR_{1Z2}	21 23 55	3				
			S_N	21 28 44	10				
			S_E	21 28 44	8				
			eM_E	21 42 08	20				
			M_Z	21 42 18	20				
			eM_{E1}	21 42 28	20				
			F	22 03±					

THE LICK OBSERVATORY STATION

CONSTANTS

Constants of the Station

Latitude and longitude of the center of the seismographic room:

$\varphi = 37° 20' 24''.5$ N. Lat.
$\lambda = 121° 38' 34''$ W. from Greenwich.

Time. All determinations are reduced to Greenwich mean civil time.

Altitude, 1281.7 meters (4202.25 feet) above mean sea level.

Constants of the Seismographs

Date	Apparatus	Component	V	T_0	ϵ	$\frac{r}{T_0^2}$
Dec. 6	Wiechert	E	95	10.0	4.8	0.0029
	160 Kg. H.	N	85	7.9	5.1	0.0048
	Wiechert	Z	59	3.1	8.0	0.0009
	80 Kg. V.					
Feb. 7	160 Kg. H.	E	110	11.1	5.3	0.0034
		N	88	7.4	6.9	0.0057
	80 Kg. V.	Z	65	3.0	7.6	0.0016
Mar. 16	160 Kg. H.	E	95	10.1	6.1	0.0030
		N	86	7.9	6.3	0.0045
	80 Kg. V.	Z	63	3.0	10.2	0.0011

LICK OBSERVATORY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Remarks
	1924			h m s	s	μ	μ	μ	
1	Nov. 13	IId	$i\overline{P}_Z$	6 23 01	<1			+3	△=59 km. about. Epicenter probably a few miles north of Santa Cruz.
			$i\overline{P}_{EN}$	6 23 06	<1	−1			
			$i\overline{S}_{EN}$	6 23 09					
			$i\overline{S}_Z$	6 23 10					
			M_{ENZ}	6 23 11	<1				
			F	6 24.8±					
2	Dec. 28	IId	$i\overline{P}_{EN}$	4 20 57	<1	−4	+14		△=60 km. about. Epicenter in neighborhood of San Juan. Record on Z not complete. Lost in microseisms.
			i_E	4 21 03					
			i_N	4 21 04					
			$i\overline{S}_{EN}$	4 21 05	<1				
			F	4 26±					
3	Dec. 29	IId	$e\overline{P}_{EN}$	7 27 19					See Berkeley report.
			i_{EN}	7 27 23					
			i_{EN}	7 27 24					
			$i\overline{S}_{EN}$	7 27 25					
			i_{EN}	7 27 27					
			i_{ENZ}	7 27 34					
			i_{EN}	7 27 39					
			F	7 29±					
	1925								
4	Jan. 18	Iu	iP_N	12 16 01					△=6660 km. See Berkeley Bulletin for location of epicenter. Not recorded on Z.
			iP_E	12 16 02	6	−2			
			i_N	12 16 23					
			i_E	12 16 27					
			i_E	12 17 39					
			i_N	12 17 42					
			iPR_{1EN}	12 18 49					
			iS_{EN}	12 24 10					
			iS_{E1}	12 24 15	13	+8			
			iS_{N1}	12 24 17	10		+27		
			iPS_E	12 24 34					
			iPS_N	12 24 35					
			i_N	12 25 48					
			i_E	12 25 52					
			iSR_{2E}	12 30 47					
			iSR_{2N}	12 31 03					
			iL_{EN}	12 31 18	33				Velocity=4.4 km./sec.
			iM_E	12 35 00					
			F	14 38±					

LICK OBSERVATORY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude			Remarks
						A_E	A_N	A_Z	
	1925			h m s	s	μ	μ	μ	
5	Jan. 18	Iv	$i\overline{P}_N$	18 16 07					△=126 km.
			$i\overline{P}_E$	18 16 08					Not recorded on Z.
			$iR_S\overline{P}_N$	18 16 18					
			$i\overline{S}_{EN}$	18 16 20					
			F	18 18±					
6	Feb. 1	Iu	e_E	9 07 40					Nothing on Z. Barely perceptible on E. and N.
			e_N	9 08 11					
			F	9 38±					
7	Feb. 1	Iu	e_E	10 08 17					
			e_N	10 08.4					
			F	10 29±					
8	Feb. 2	Iu	eP_E	19 57 41	3				△=7220 km.
			eP_N	19 57 59	3				See Berkeley Bulletin for location of epicenter. Not recorded on Z. Velocity=4.3 km./sec.
			eS_N	20 06 21	4				
			eS_E	20 06.4	11				
			eL_N	20 15 11	18				
			eL_E	20 16 29	20				
			eM_E	20 20 06					
			eM_N	20 20 19					
			F	21.4±					Lost in microseisms.
9	Feb. 9	Iu?	eL_E	14 50 25	27				Heavy microseisms on E.-W. component. Barely perceptible.
			eL_Z	14 51 13					
			eL_N	14 51 19					
			iM_E	14 53 20	18				
			M_{E1}	14 57 27	17	+20			
			F	15 21±					
10	Feb. 10	Id	$i\overline{P}_{EN}$	9 05 32					Vertical record illegible. The phases are beautifully separated on both horizontal components. The periods are all very short and the amplitudes small. △=67 km. The epicenter lies in the Crystal Springs Lake.
			$i\overline{S}_{EN}$	9 05 41					
			iM_{EN}	9 05 42					
			F	9 06±					

LICK OBSERVATORY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude			Remarks
						A_E	A_N	A_Z	
	1925			h m s	s	μ	μ	μ	
11	Feb. 23–24	Ir	iP_Z	23 59 41	4			−<3	△=1960 km. See Berkeley Bulletin for location of epicenter.
			iP_N	23 59 46	5		+ 2		
			i_N	23 59 53	6		− 2		
			i_E	23 59 57	5	− 2			
			i_Z	23 59 57	3			+2	
			iS_N	0 04 38	8		−16		
			iS_E	0 04 40	5	− 2			
			eS_Z	0 04 45	6			−<6	
			i_E	0 05 50	6	− 3			
			i_N	0 06 15	11		+ 5		
			iM_E	0 07 52	22	−74			
			iM_{E1}	0 08 44	24	+124			
			iM_{N1}	0 08 44	12		+27		
			F	0 40±					Lost in microseisms.
12	Mar. 21	Id	$i\overline{P}_Z$	12 27 38					△=14 km.
			$i\overline{P}_{EN}$	12 27 39					
			$i\overline{S}_Z$	12 27 40					
			$i\overline{S}_{EN}$	12 27 41					
			F	12 28±					
13	Mar. 22	Iu	eP_E	8 54 38					
			eP_N	8 54 40					
			ePS_E	9 05 13					
			ePS_N	9 05 20					
			$iPPS_E$?	9 06 22					
			$iPPS?_N$	9 06 27					
			$iPPS?_{E1}$	9 06 30	21	+63			
			e_E	9 15 40					
			e_N	9 17 54					
			eL_E	9 20 46	28				V=3.8 km./sec.
			eL_N	9 21 04	34				
			iM_E	9 23 11	20	+11			Velocity=3.6 km./sec.
			iM_N	9 23 45					
			iM_{E1}	9 23 54	23	+60			
			W_{2E}	11 05 14	17				V=3.7 km./sec.
			W_{3E}	12 15 43	17				V=3.8 km./sec.
			F	12 34±					
14	Mar. 29	Id	$i\overline{P}_N$	2 24 17					Record on Z imfect at this time.
			i_{EN}	2 24 21					
			i_N	2 24 24					
			i_E	2 24 25					
			i_N	2 24 26					

LICK OBSERVATORY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Remarks
	1925			h m s	s	μ	μ	μ	
14	Mar. 29	Id	i_N	2 24 30					
	(contd.)		i_E	2 24 35					
			i_E	2 24 45					
			i_N	2 24 50					
			i_E	2 24 54					
			F	2 26±					
15	Mar. 29	Id	$i\overline{P}_{EN}$	6 08 44					△=60 km.
			$i\overline{P}_Z$	6 08 46					
			$i\overline{S}_{ENZ}$	6 08 52					
			i_Z	6 08 54					
			F	6 12±					
16	Mar. 29	Id	$i\overline{P}_{NZ}$	18 01 07					△=60 km.
			$i\overline{P}_E$	18 01 08					
			i_N	18 01 11					
			$i\overline{S}_{ENZ}$	18 01 15					
			i_{EN}	18 01 18					
			F	18 04±					Lost in microseisms.
17	Mar. 29	Ir	eP_E	21 21 28	6	+<1			Not recorded on N. nor Z. △=5580 km. Epicenter approximately λ=105° W, φ=5° S.
			iPR_{2E}	21 24 27					
			i_E	21 28 26					
			iS_E	21 28 35					
			eL_E	21 32 32	12				
			M_E	21 42 57					
			F	21 58±					