THE REGISTRATION OF EARTHQUAKES AT THE BERKELEY STATION

AND

AT THE LICK OBSERVATORY STATION

FROM

October 1, 1927, to March 31, 1928

BY

PERRY BYERLY

AND

KARL DYK

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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.
$\overline{P_cP_c}$ $\overline{P_cP}$	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.
G	Long waves at beginning of surface phase. Velocity about 4.4 $\frac{km.}{sec.}$
L (undae longae)	Long waves preceding M. Velocity about 3.8 $\frac{km.}{sec.}$
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:

$\overline{P}$	The longitudinal wave which has traveled its whole path in the surface layer of the earth.
$\overline{S}$	The transverse wave which has traveled its whole path in the surface layer of the earth.
P*	The longitudinal wave which has penetrated only as deep as the second layer of the earth's crust.
S*	The corresponding transverse wave.

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 ($\mu = \frac{1}{1000}$ mm.), + 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.

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CONSTANTS

Latitude and longitude of the center of the seismographic room:

$\varphi = 37° 52' 15''.9$ N. Lat.
$\lambda = 122° 15' 36''.6$ 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_0	ϵ	$\frac{r}{T_0^2}\left(\frac{cm}{sec^2}\right)$
1927						
Nov. 26	Bosch-Omori 100 kg.	E	37	11.8	5	0.002
	"	N	43	11.7	2	0.003
	Weichert 80 kg.	Z	40	5.4	5	0.005
1928						
Feb. 3	Bosch-Omori 100 kg.	E	41	11.8	6	0.002
	"	N	40	11.7	2	0.004
	Wiechert 80 kg.	Z	40	5.3	4	0.004

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No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1927			h. m. s.	s.	μ	μ	μ	
1	Oct. 5	Iv	e_E	9 18 19	6				Felt in Imperial valley. May begin earlier. Microseisms present.
			e_Z	9 18 43					
			e_Z	9 19 25	3				
			F	9 23±					
2	Oct. 24	IIIr	eP_{ENZ}	16 04 48	7_{EN}	− 2	+ 2	+ 10	About R-F 7 at Sitka, Alaska. Pen thrown off record on E-W but replaced.
					6_Z				
			i_{EN}	16 04 52	6_E	− 12			
			i_E	16 05 15	7	− 15			
			e_E	16 05 31	16	− 20			
			i_Z	16 06 58	6			+ 13	
			i_N	16 07 05	5		+ 8		
			e_E	16 07 06	7	+ 15			
			eS_Z	16 08 54	10				
			iS_E	16 08 57	25	+450			
			iS_N	16 09 01	18		+ 85		
			e_E	16 09 59	16				
			i_N	16 10 17	20		+600		
			i_N	16 10 32	30		+650		
			e_Z	16 10 36	15				
			i_E	16 10 39	25	−1100			
			i_N	16 11.8	15		−150		
			i_E	16 12.0	15	−600			
			F	19 35±					
3	Nov. 4	IIIv	eP_Z	13 51 48	4			+ 4	See note at end of this bulletin.
			eP_{EN}	13 51 49	4	− 3	+ 2		
			iP^*_Z	13 51 53	4			+ 10	
			iP^*_E	13 51 54	10	+ 13			
			iP^*_N	13 51 55	4		± 8		Might be a crest earlier.
			$i\overline{P}_N$	13 52 01	16		+ 70		
			$i\overline{P}_E$	13 52 05	14	− 45			
			$i\overline{P}_Z$	13 52 06	16 ca.			−450	
			iS_E	13 52 30	9	−180			
			$i\overline{S}_{NE}$	13 52 51	4_N	−280	−360		
					6_E				
			$i\overline{S}_Z$	13 52 53	6			+650	
			iM_Z	13 53 30	9			+2400	
			i_E	13 53 06					Pen leaves record.
			i_N	13 53 21?					Pen leaves record.
			F	17 32±					

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1927			h. m. s.	s.	μ	μ	μ	
4	Nov. 4		eP_{EZ}	18 49 17	3_E	− 3			
					4_Z			− 2	
			eP_N	18 49 18	2		− 2		
			$e?_E$	18 49 32	2	+ 5			
			F	18 55.1±					
5	Nov. 4	I	$e?_E$	19 01 42					May be microseisms.
6	Nov. 4	Iv	eP_{NZ}	20 01 40	6_Z			+ 8	
			e_E	20 02 25					Earlier phase present —very weak.
			e_N	20 02 44	1		+ 5		
			ze_N	20 02 47	3		+ 4		
			e_E	20 02 59	4	+ 18			
			e_E	20 04 13	8	− 9			
			F	20 13±					
7	Nov. 4	Iv	eP_{EN}	20 45 39					
			e_Z	20 45 47					
			$e?_N$	20 45 53	2		+ 4		
			$e?_E$	20 45 56	2	− 5			
			F	20 54±					
8	Nov. 5	Iv	eP_E	3 25 38	3	+ 3			
			e_N	3 25 45	2		+<2		May begin earlier.
			e_E	3 27 02	5	+			Disturbance hardly perceptible on Z.
			e_E	3 30 16		+			
			F	3 36±					
9	Nov. 5	Iv	eP_E	3 40 02	3	− 3			May begin earlier.
			eP_N	3 40 03					
			e_Z	3 40 19	4			− 4	Sinusoidal.
			eS_E	3 40 33	3	+ 10			
			eS_N?	3 40 34	3		+ 2		
			e_N	3 40 48	2		+ 5		Sinusoidal.
			F	3 50±					
10	Nov. 5	Iv	eP_E	3 53 19					
			e_N	3 53 23					
			e_Z	3 53 36	5			− 2	
			e_E	3 53 47	2	+			
			F	3 59±					

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1927			h. m. s.	s.	μ	μ	μ	
11	Nov. 5	Iv	eP_Z	9 02 09					
			eP_E	9 02 10					
			eP_N	9 02 11					
			e_{NZ}	9 02 45	4_Z			− 4	
					3_N				
			e_N	9 02 57	2		+ 4		
			$eS?_E$	9 03 02	8				
			F	9 10±					
12	Nov. 6		eP_Z	2 40 40	4			− 2	
			eP_N	2 40 42			+		
			eP_E	2 40 46		−			
			e_E	2 41 00	2	+ 2			
			e_{EN}	2 41 14	1_E	+ 5			
					1_N		− 9		
			e_{NZ}	2 41 23	4_N		+ 50		
					4_Z			− 10	
			e_E	2 41 39	7	+ 20			
			eM_{IE}	2 42 57					
			i_N	2 43 59	6		−360		
			e_Z	2 44 50	6			− 30	
			F	2 57±					
13	Nov. 8		e_Z	3 30 40	4			− 2	
			$e?_E$	3 31 04					Microseisms present.
			$e?_E$	3 32 36					
			$e?_E$	3 35 15					
			$e?_Z$	3 36 11	3			+ 4	
			$e?_Z$	3 36 28	4				
			$e?_E$	4 48	40				Beginning poorly defined.
			F	5 05±					
14	Nov. 10	Iv	eP_{EN}	16 48 03	4_E	− 3	+		Microseisms present.
			eP_Z	16 48 04				−	
			e_N	16 48 32	2		+ 5		
			e_{EZ}	16 48 33	2_E	− 11			
					4_Z			− 6	
			F	16 55±					
15	Nov. 12	I	e_E	0 54.5±					Beginning obscure.
			e_Z	0 55.0±					May be microseisms.
			F	1 08±					

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1927			h. m. s.	s.	μ	μ	μ	
16	Nov. 14	Iu	eP_{EZ}	7 31 51	6_E	− 5		+ 2	
					4_Z	+ 0		− 8	
			eP_N	7 31 57					May begin earlier.
			e_Z	7 32 07	3			− 6	
								+ 6	Macelwane's epicenter in Northern Siberia.
			e_{EN}	7 32 08	3_E	− 3	−<2		
					3_N	+ 3	+<2		
			eS_E	7 42 10	6	+ 5			
						− 5			
			eS_N	7 42 11	7		+ 2		
							0		
			eS_Z	7 42 12	6			+<3	
								−<3	
			e_E	7 42 23					
			F	7 52±					
17	Nov. 15	Ir	eP_{ENZ}	8 37 16	2_Z			− 2	
								+ 2	
			e_Z	8 37 34	3			− 2	
								+ 2	
			eS_E	8 43 33	8	− 6			
						+ 6			May also be on N.
			eS_Z	8 43 34	8				
			eSR_{ZE}	8 47 37	15	+ 2			
			F	8 59±					
18	Nov. 16	Iu	e_E	21 34 43	17	− 2			May begin earlier.
			e_E	21 57 14	40	+ 30			
						− 60			
			e_Z	21 57 19	35			+<100	
								−<100	May begin earlier.
			e_E	22 20 54	20	− 6			
						+ 6			
			F	22 48±					
19	Nov. 19	Iv	eP_{NZ}	3 33 27					Cracked windows and knocked down a few chimneys at Santa Maria.
			eS_E	3 34 00	6	+ 1			
						− 1			
			eS_{NZ}	3 34 01	3_Z			− 2	
			e_N	3 34 08			+		
			e_Z	3 34 09	6			+ 5	
								− 5	
			e_E	3 34 13	2	− 3			

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1927			h. m. s.	s.	μ	μ	μ	
	Nov. 19 (contd.)		e_N	3 34 14					
			e_{NZ}	3 34 41	4_N		+ 6		
			F	3 43±					
20	Nov. 21	I	e_Z	23 29 35	3			−<2	
								+<2	
			e_E	23 36 09	14	− 2			
			e_E	23 37 10	9	− 9			
			e_E	23 52 25±	45	−190			
						+150			
			e_Z	23 56 58	30			−<8	
								+<8	
			e_E	23 58 35±	25	+ 30			
						− 30			
			e_E	1 03 44					
			e_E	1 27 25±	60?	+<70			Beginning doubtful.
						−<70			
			i_Z	1 33 15					Group of short period wave of small amplitude.
			i_Z	1 33 20					
			i_Z	1 33 48					
			i_Z	1 34 06					
			i_Z	1 34 09					
			i_Z	1 34 39					
			i_Z	1 34 49					
			F	1 58±					
21	Dec. 2	Id	$i\overline{P}_{ENZ}$	4 33 07		− 5	− 2		About R–F 6 at Concord, Calif. and Alamo, Calif.
			i_N	4 33 08			+ 7		
			i_N	4 33 09			− 7		
			$i\overline{S}_{ENZ}$	4 33 10		− 9	+ 40		
						+ 16	− 20		
			i_{NZ}	4 33 11					
			i_N	4 33 12			+ 7		
			F	4 34.0±					
22	Dec. 20	I	e_E	3 35 00	5				
			e_N	3 35 42	6				
			F	3 42.0±					
23	Dec. 28	Iu	eP_{EZ}	18 29 48	8_{EZ}	−<1		− 9	
						+<1		+ 14	
			eP_N	18 30.0	9		− 1		Time poor.
							+ 1		

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1927			h. m. s.	s.	μ	μ	μ	
	Dec. 28 (contd.)		e_N	18 32 09	10		−<1		
							+<1		
			eS_{EN}	18 37 37	20_{EN}	+ 90	− 45		
						−120	+ 65		
			eS_Z	18 37 45	20			−<30	
								+100	
			$eSR_1?_E$	18 40 59	13	− 3			
						+ 6			
			$eSR_1?_Z$	18 41 09	20			− 65	
								+ 65	
			$eSR_1?_N$	18 41 25	10		+ 1		
							− 1		
			$eSR_2?_N$	18 43 31	25		− 40		
							+ 80		
			$eSR_2?_E$	18 43 33	25	− 50			
						+150			
			$eSR_3?_Z$	18 45 03				−100	
								+<100	
			$eSR_3?_E$	18 45 19	35	+ 45			
						−110			
			eL_N	18 47 38					
			eL_E	18 47 44	20	− 45			
						+ 60			
			$eM?_Z$	18 50 18	20			− 65	
								+ 65	
			F	20 31±					
24	Dec. 31	I	e_Z	19 08.7±					
			e_Z	19 09.8±					
			e_E	19 14 01±	7	+<2			
						−<2			
			e_N	19 14 27	8		+ 1		
			F	19 28±					
	1928								
25	Jan. 1	Ir	eP_Z	9 31 59	7			−<3	
								+<3	
			eP_E	9 32 06					
			eS_{EN}	9 37 09	10_N		+ 2		
							− 1		
			e_N	9 37 16	20		+ 5		
							− 5		
			$eSR_1?_E$	9 39 01	14	−<3			
						+<3			

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No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Remarks
	1928			h. m. s.	s.	μ	μ	μ	
	Jan. 1 (contd.)		e_E	9 40 09±	30?	−<15			
						+<15			
			e_E	9 42 48±	15	− 10			
						+ 10			
			e_Z	9 43 14	15			−<20	
								+<20	
			e_N	9 43 32	12		− 5		
							+ 5		
			e_E	9 44 01	12	− 5			
						+ 14			
			e_E	9 47 06	10	− 4			
						+ 11			
			e_N	9 49 01	10		+ 2		
							− 5		
			e_E	9 49 36	7	−<2			
						+<2			
			F	9 58±					
26	Jan. 6	I	e_Z	19 54 07±	8			− 4	Motion slight on all components. Microseisms present.
								+ 4	
			e_E	20 37 04	35	−<3			
						+<3			
			e_N	20 37					
			F	21 22±					
27	Jan. 8	Iv	eP_{ENZ}	2 00 39					Beginning in time break.
			e_E	2 00 43	3	+ 2			
			e_Z	2 00 46	3			− 2	Felt at Salinas and Hollister, Calif.
			e_Z	2 00 50	2				
			e_N	2 00 54	3		− 5		
			e_N	2 00 56	2		− 2		
			e_N	2 01 03					
			e_E	2 01 14					
			e_Z	2 01 20					
			F	2 03.0±					
28	Jan. 9	Iv	eP_Z	2 45 42	3			− 2	
			eP_N	2 45 44					
			eP_E	2 45 46					
			eS_{EN}	2 45 57	3_E	− 5	− 2		Knocked merchandise from shelves at Gilroy, Calif.
					2_N		+ 10		
			eS_Z	2 45 58	3			− 5	Also felt at Salinas, Hollister, and Watsonville.
								+ 5	
			i_E	2 46 03	2	+ 9			

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No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Remarks
	1928			h. m. s.	s.	μ	μ	μ	
	Jan. 9		e_N	2 46 12					
	(contd.)		e_Z	2 46 14	1			− 4	
								+ 6	
			e_E	2 46 16	7	− 2			
						+ 2			
			e_N	2 46 23					
			e_Z	2 46 27					
			e_N	2 46 32	4		+ 2		
							− 2		
			e_Z	2 46 33					
			e_Z	2 46 58	1			−<2	
								+<2	
			F	2 48.0±					
29	Jan. 15	Id	iP_{NE}	22 22 42					
			iS_{EN}	22 22 44					
			i_N	22 42 45					
			i_N	22 42 46					
			F	22 22 52±					
30	Jan. 20	Iu	e_E	4 16 48	20	− 6			Reported felt at Lima, Peru. N starts in time mark.
						+ 12			
			e_{NZ}	4 16 55	20_N		+		
					15_Z				
			F	4 29±					
31	Feb. 10	Ir	eP_N	4 44 25	3		+<2		Reported felt at Mexico City.
							−<2		
			eP_E	4 44 26	4	+<2			
						−<2			
			eP_Z	4 44 27	4			− 2	Macelwane's epicenter 19.8° N, 98.5° W.
								+ 2	
			e_Z	4 45 38	4			+<2	
								−<2	
			e_N	4 45 44	4		+<2		
							−<2		
			e_Z	4 53 40	9			−<6	
								+<6	
			F	5 08±					
32	Feb. 21	Iv	eP_E	19 56 42	3_E	−<2		−<2	
					4_Z	+<2		+<2	
			eP_N	19 56 43	5		+<2		
							−<2		

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1928			h. m. s.	s.	μ	μ	μ	
	Feb. 21		e_Z	19 56 55	4			− 2	
	(contd.)		e_N	19 58 19	5		+<2		Two shocks felt at Calexico, Calif.
							−<2		
			e_Z	19 58 24	5			−<2	
								+<2	
			e_{EN}	20 02 54	6_E	−<2			E indefinite.
						+<2			
			e_N	20 06 13	9		+ 1		
							− 1		
			e_N	20 14 09	12		+<1		Amplitude gradually increases.
							−<1		
			e_N	20 18 09	12		+ 3		
							− 3		
			F	21 06±					
33	Feb. 26	I	e_Z	1 26 47	2				Microseisms present on horizontals. Beginnings in doubt.
			e_E	1 26 54					
			e_E	1 36.0					
			e_Z	1 36 15					
			e_N	1 36 20					
			e_E	1 39 35	12	− 3			
						0			
			e_E	1 44 06	10	− 2			Marked change in period.
						+ 2			
			e_N	1 44 31	10		+<6		
							−<6		
			F	2 15±					Lost in microseisms.
34	Mar. 2	Id	eP_{ENZ}	1 10 13				+<2	Beginning indefinite on N and E.
			eS_E	1 10 24					
			eS_{NZ}	1 10 26	1		− 10	+<2	
							+ 7	− 2	
			F	1 12.0±					
35	Mar. 9	Iu	eP_Z	18 24 50	2			+<2	May possibly be on N also.
								−<2	
			e_E	18 24 58	3	−<2			
						+<2			Macelwane's epicenter in Indian Ocean south of Bengal.
			e_Z	18 27 24	4			− 4	
								0	
			e_N	18 27 26	4		−<2		
			e_E	18 27 30	8	− 2			
						+<2			

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1928			h. m. s.	s.	μ	μ	μ	
	Mar. 9		e_E	18 27 51	8	− 6			
	(contd.)					+ 6			
			e_E	18 28 31	6	− 7			
						+ 7			
			e_E	18 32 11	5	− 2			
						+ 2			
			e_E	18 45 35	60	−280			
						+410			
			$eG?_E$	19 02 42	40	−240			
			$eL?_E$	19 09 46	30	− 12			
						+ 12			
			F	21 35±					
36	Mar. 13	I	eP_Z	18 45 00	4			+<2	
								−<2	
			e_E	18 45 11	4	−<2			
						+<2			
			e_E	18 47 49	4	−<2			
						+<2			
			e_Z	18 48 04	4			+<2	
								−<2	
			e_N	18 55 17	6		+ 2		
							0		
			e_E	18 55 50	7	+<2			
						−<2			
			e_E	19 10 50	40	−<30			
						+<30			
			e_E	19 12 10	30	+ 15			
						− 15			
			F	19 28±					
37	Mar. 16	Iu	eP_{EN}	5 13 51	2	+<2	+<2		U. S. C. G. S. epicenter 23.0° S, 170.4° E.
			eP_Z	5 13 52	2			+ 2	
								0	
			$e_Z?$	5 17 23	2			±<2	
			$e_N?$	5 18 09					
			eS_N	5 24 14	6		−<2		
							+ 4		
			eS_E	5 24 17	8	+ 4			
						− 6			
			eG_N	5 37 39	40		− 30		v=4.4 km/sec.
							+ 40		

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude A$_E$	Amplitude A$_N$	Amplitude A$_z$	Remarks
	1928			h. m. s.	s.	μ	μ	μ	
	Mar. 16 (contd.)		eG$_E$	5 37 42	40	+ 70			
						− 55			
			eL$_Z$	5 41 24	30			−600	
								+750	
			eL$_E$	5 41.7	30	+170			
						−180			v=4.0 km/sec.
			eL$_N$	5 47.8	25		+ 20		
							− 45		
38	Mar. 18	I	e$_N$?	3 16 55					U. S. C. G. S. epicenter at 14° N, 95° W.
			e$_Z$	3 16 56					
			e$_N$?	3 45.5	30 ca		+<15		
			e$_E$	3 45.5	30 ca	+<80			
						−<80			
			e$_Z$	4 16.3	30 ca			+<15	
								−<15	
			F	4 21±					
39	Mar. 22	IIIr	eP$_{EN}$	4 23 27	13$_E$	− 8	+ 2		
					10$_N$	+ 13	− 4		
			eP$_Z$	4 23 28	4			+<2	
			ePR$_{iEN}$	4 24.6	15	− 10	+ 2		
						+ 10	− 4		
			e$_Z$	4 24.7	5			− 6	
								+ 6	
			eS$_E$	4 28 45	8	+ 10			
						− 17			
			iS$_N$	4 28 46	8		+ 20		
							− 30		
			e$_Z$	4 29 17	28			−350	
								+350	
			eG$_N$	4 32.0	40		−1100		
							+1000		
			eG$_E$	4 32.1	40	+1000			
						−1250			
			iL$_{EN}$	4 32.8	30	+1050	+1100		
						−1450	−1500		
			eL$_Z$	4 32.8	25 ca			−110	
			i$_Z$	4 36.3	20			−1000	
								+100	
			F	6 57±					

BERKELEY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude A$_E$	Amplitude A$_N$	Amplitude A$_z$	Remarks
	1928			h. m. s.	s.	μ	μ	μ	
40	Mar. 26	Id	eP$_{ENZ}$	16 27 48		−	−<2		Microseisms on Z.
			eS$_E$	16 27 53					
			eS$_N$	16 27 54			+<2		
			e$_N$	16 27 55	3		+ 9		
							− 9		
			e$_{ENZ}$	16 27 58	3$_{EN}$	− 7	+ 7	−<2	
					2$_Z$	+ 7			
			F	16 31.7±					
41	Mar. 31	Iu	eG?$_E$	1 18.6±	50	−<50			Felt at Constantinople.
						+<50			
			eG?$_N$	1 20±	50?		+<50		Not registered on Z.
							−<50		
			eL?$_E$	1 28.3	20	−<6			
			eL?$_Z$	1 28.4	20			−<30	
			eL?$_N$	1 28.6	20		+<6		
			F	1 45±					

THE LICK OBSERVATORY STATION

CONTENTS

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	$\frac{r}{T_0^2}$
1927						
Dec. 23	Wiechert	E	93	9.2	5	0.003
	160 Kg. H.	N	88	7.2	6	0.0005
	Wiechert	Z	52	3.2	7	0.0008
	80 Kg. V.					

LICK OBSERVATORY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Remarks
	1927			h. m. s.	s.	μ	μ	μ	
1	Oct. 5	Iv	ePE	21 17 43					Felt in Imperial Valley.
			e_E	21 17 55					
			e_E	21 18 04					
			e_N	21 18 10					
			eS_N	21 18 16					
			iS_E	21 18 16	2	− 1			
			e_N	21 18 23		+ 1			
			e_E	21 18 43					
			e_N	21 18 45					
			e_N	21 19 06					
			i_E	21 20 06	3				
			F	21 52±					
2	Oct. 16	Id	ePE	15 03 04					
			ePN	15 03.1					
			eS_E	15 03 13					
			eS_N	15 03 17					
			F	15 05.0±					
3	Oct. 24	IIIr	ePN	16 04 59	6		− 8		U. S. C. G. S. epicenter at 59° N, 139° W.
			e_N	16 05 04	6		− 6		
							+ 6		
			$ePR_1?_N$	16 05 19					
			e_N	16 07 28					About R–F 7 at Sitka, Alaska.
			e_N	16 07 45	5		+ 4		
							− 4		
			iS_N	16 09 16	12		+120		
							−220		
			$iG?_N$	16 09.9	32		+1300		
							−950		
			iL_N	16 12.1			+180		
							−270		
			F	11 55±					
4	Nov. 4	IIIv	iPn_N	13 51 41	3		+ 2		
			ePn_Z	13 51 41	2	+<2			
			ePn_E	13 51 43	3	− 1			
			iP^*_{ENZ}	13 51 45	9_E	− 30	+ 7	+ 40	
					6_N				
					7_Z				

LICK OBSERVATORY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1927			h. m. s.	s.	μ	μ	μ	
	Nov. 4 (contd.)		$i\overline{P}_{EN}$	13 51 53	11_E	+110	− 40		
					13_N				
			i_Z	13 51 56	4			+ 75	Short period also superposed on horizontals.
			iS_E	13 52 30	6	−>60			Pen bumped.
			iS_Z	13 52 33	3			+>200	Pen bumped.
			iM_N	13 52 44	6		+ 60		
			iM_Z	13 52 44	3			− 50	
			F	16 20±					
5	Nov. 4	Iv	eP_N	18 48.3±					Beginning doubtful
			i_{NE}	18 48 52					
			e_N	18 49 03					
			i_N	18 49 27					
			F	18 50.8±					
6	Nov. 4	Iv	iP_E	20 01.6					
			eP_N	20 01.6					
			eP_Z	20 01 40					
			i_N	20 01 50	2		+ 1		
							− 1		
			iS_N	20 02 14	< 2		+ 4		
			eS_Z	20 02 15					
			e_Z	20 02 35					
			F	20 05±					
7	Nov. 4	Iv	eP_N	20 44 57					
			eP_E	20 45 00					
			i_N	20 45 24					
			i_E	20 45 29					
			i_E	20 45 34	3	+ 2			
						− 5			
			i_N	20 45 35					
			i_N	20 45 44					
			F	20 46±					
8	Nov. 5	Iv	eP_{EN}	3 39.4					
			e_N	3 40 04					
			e_Z	3 40 18					
			F	3 41.0±					

LICK OBSERVATORY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1928			h. m. s.	s.	μ	μ	μ	
9	Nov. 5	Iv	eP_{EN}	3 52.7±					
			e_N	3 53 18					
			e_E	3 53 30	2	− 3			
			e_N	3 53 32					
			F	3 55.0±					
10	Nov. 5	Iv	e_N	9 01 58					Earlier phase present —very weak.
			i_N	9 02 08					
			e_E	9 02 20					Earlier phase present —very weak.
			i_N	9 02 27					
			i_N	9 02 34					
			e_E	9 02 42					
			F	9 06±					
11	Nov. 6	Id	$i\overline{P}_{ENZ}$	18 47 18	1 ca	+ 2	− 2	− 2	
			i_{NZ}	18 47 19	1 ca		+ 5		
			i_N	18 47 22					
			i_{NZ}	18 47 24					
			$i\overline{S}_{EN}$	18 47 25	1 ca	− 5	+ 5		
							− 8		
			i_N	18 47 29	3		− 30		
							+ 24		
			i_Z	18 47 35	4			+ 15	
								− 18	
			e_{EN}	18 48 02	1_N ca		+ 4		
			F	18 50±					
12	Nov. 7	Id	$i\overline{P}_E$	1 09.9	1 ca	+ 1			
			$i\overline{P}_N$	1 09 54	1 ca		+<1		
			$i\overline{P}_Z$	1 09 56	1 ca			− 4	
			$i\overline{S}_E$	1 10.0	1 ca	− 3			
			$i\overline{S}_N$	1 10 02	1 ca		− 7		
			i_Z	1 10 05					
			i_N	1 10 06					
			i_Z	1 10 11					
			F	1 12±					
13	Nov. 10	I	eP_N	16 47 46					Line of rest shifted. Registered on Z but lines retraced.
			eP_E	16 47 48±					
			$iS?_N$	16 48 05					
			$iS?_E$	16 48 09					
			F	16 48.7±					

LICK OBSERVATORY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1927			h. m. s.	s.	μ	μ	μ	
14	Dec. 28	Iu	eP_N	18 29 53±			+		Time difficult.
			eP_E	18 29 56	12	− 1			
						+ 2			U. S. C. G. S. epicenter 55° N, 160° E.
			e_E	18 37 08	12	+<1			
						− 2			
			eS_N	18 37 41±	20		+ 5		
							− 20		Did not register on Z.
			eS_E	18 37 44	30	+190			
						−230			
			$eSR_1?_E$	18 41 29	15	+ 2			
						− 6			
			$eSR_3?_N$	18 43 52	25		− 25		
							+ 90		
			$eSR_3?_E$	18 43 54	25	− 30			
						+ 90			
			e_N	18 49 53	12		+ 3		
							− 3		
			e_E	18 51 11	18	+ 15			
						− 30			
			e_E	18 59 45	17	− 5			
						+ 10			
			F	20 11±					Lost in microseisms.
	1928								
15	Jan. 1	Ir	eP_E	10 31 59	4	+<1			
						−<1			
			eS_E	10 36 54	12	− 1			
						+ 1			
			eL_E	10 40.8	25	− 12			
						+ 12			
			eL_N	10 40.9	25		+<10		
							−<10		Macelwane's epicenter 14.3 N, 99.8 W.
			e_E	10 42.5	15	− 6			
						+ 6			
			e_N	10 43.3	15		+ 3		
							− 3		
			e_N	10 44.7	10		− 2		
							+ 2		
			e_E	10 44.8	12	− 6			
						+ 15			
			e_E	10 46.5	8	− 3			
						+ 3			
			F	11 06±					

LICK OBSERVATORY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1928			h. m. s.	s.	μ	μ	μ	
16	Jan. 6	IIv	eP_{EN}	2 41.0	< 1	+<1	+<1		
			eP_Z	2 41 02	< 1			−<2	
			i_{ENZ}	2 41 05	< 1_Z			+<2	
			i_{ENZ}	2 41 08	1 ca_Z			+ 2	
			iS_Z	2 41 17	2			+ 8	
								− 8	
			iS_{EN}	2 41.3	2	+ 5	− 5		
			iM_{1E}	2 41.9	6	− 80			
						+ 65			
			iM_{1N}	2 42.4	7		+ 95		
							− 95		
			F	2 55±					
17	Jan. 8	Iv	$eP?_E$	2 00 09					Felt at Salinas.
			i_E	2 00 10	1 ca	+ 2			
						− 2			
			i_N	2 00 11					Pen bumped. Displacements only to north.
			i_N	2 00 15					
			i_{EN}	2 00 16					
			i_{EN}	2 00 18	6_N	+ 20	+400		Z record illegible.
			i_E	2 00 25					
			i_N	2 00 29					
			F	2 00.7±					
18	Jan. 9	IId	iP_{ENZ}	2 45 31	1 ca		+ 1	−<2	
								+ 4	
			i_N	2 45 34					
			$i_{EZ}?$	2 45 34					
			iS_{ENZ}	2 45 36	1 ca_Z			− 6	Underlying phase of 6 sec. on N.
					<1_N			+ 8	
			i_Z	2 45 45				− 6	Felt at Gilroy, Hollister, and Watsonville. Knocked merchandise from store shelves at Gilroy.
			i_N	2 45 48					
			i_Z	2 45 51					
			i_E	2 45 55					
			F	2 46.0±					
19	Jan. 13	IId	iP_N	7 04 52	1 ca		+ 14		Reported felt at San Jose and Lick Observatory.
			iP_E	7 04 53	1 ca	+ 4			
			iS_{EN}	7 04 54	1 ca	± 80	+ 60?		
			i_N	7 05 04	6		+ 6		
			F	7 06 07±					

LICK OBSERVATORY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1928			h. m. s.	s.	μ	μ	μ	
20	Jan. 20	Iu	e_E	5					Surface waves registered—no hour or minute marks. Felt at Lima, Peru.
21	Jan. 21	Id	iP_{EN}	4 01 00±					Time marks obscure phases difficult.
			i_N	4 01 05±					
			$iS?_{EN}$	4 01 09±					
			F	4 07±					
22	Feb. 9	Ir	ePE	4 44 25	3	− 1			Felt at Mexico City. Macelwane's epicenter 19.8° N, 98.5° W.
						0			
			e_E	4 54 11	5	+ 2			
						0			
			F	5 03±					
23	Mar. 1	IId	$i\overline{P}_{EN}$	1 10 01	1	+ 5	− 4		
						− 4			
			$i\overline{P}_Z$	1 10 03	1 ca			+ 2	
								− 10	
			$i\overline{S}_{EN}$	1 10 05	2_E	− 8			
			$i\overline{S}_Z$	1 10 07	1			− 2	
								+ 2	
			i_Z	1 10 16	2			+ 12	
								− 16	
			F	1 11 04±					
24	Mar. 9	Iu	ePE	18 27 35	6	− 2			
						+ 2			
			e_E	18 27 59	10	− 6			
						+ 6			
			e_E	18 28 49	10	− 4			
						+ 7			
			e_E	18 45 36	15	+ 4			
			e_E	18 45 45	50	−110			
						+185			
			e_E	19 03.0±	40	− 90			
			e_E	19 10.7	55	−120			
						+120			
			e_E	19 23.5	25	− 6			
						+ 6			
			F	21 07±					

LICK OBSERVATORY STATION

No.	Date	Character	Phase	Time G. M. C. T.	Period	Amplitude AE	Amplitude AN	Amplitude AZ	Remarks
	1928			h. m. s.	s.	μ	μ	μ	
25	Mar. 15	I	e_Z	5 41.9±	30			−<180	
								+<180	
			e_Z	5 42.9±	25			−<120	
								+<120	
			$e?_Z$	5 48.9	15			+ 45	
								− 45	
			F	6 01±					
26	Mar. 22	Ir	ePZ	4 23 24	2			+ 2	
								0	
			e_Z	4 23 28	4			− 10	
			e_Z	4 29.3	35			−750	
								+750	
			e_Z	4 32 41	8			+ 25	
								− 25	
			e_Z	4 34.0	4			− 30	
								+ 15	
			e_Z	4 34.9	20			+800	
								−1500	
			e_Z	4 36.5	15			+450	
								−1100	

The California Earthquake of November 4, 1927

BY

PERRY BYERLY

On the morning of November 4, 1927, at about 5:51 o'clock, there occurred an earthquake which was felt in California from Morgan Hill on the north to Redondo Beach on the south and from the coast on the west to Sanger on the east.

The results of this earthquake were investigated in the field by the writer and this investigation was supplemented by questionnaires sent out from the Berkeley Seismographic Station and by the United States Coast and Geodetic Survey. The latter were kindly loaned by the Survey.

The accompanying table gives the Rossi-Forel intensity at each of the towns as it was rated by the writer. The letter *f* following the rating denotes that the data regarding the intensity at that point were obtained by the writer in the field. The letter *r* in a similar position indicates that the data were obtained from written reports or answers to questionnaires.

From the seismograms recorded at Tucson, Berkeley, and Lick Observatory, the epicenter was located at 121° 24′ west longitude, 34° 32′ north latitude.

This earthquake will be fully discussed in an early number of the Bulletin of the Seismological Society of America.

TABLE

Intensity IX

Honda (*f*). Several hundred thousand cubic feet of sand were shaken down from the cliff to the beach below.

Roberds Ranch (*f*). Man thrown from feet; house shifted on foundations; chimney thrown down; earthquake fountains; earth lurches and cracks in ground.

Surf (*f*). People thrown from beds; sand-blows and cracks in sand; concrete highway cracked; small dirt-falls; railroad bridge thrown out of line.

White Hills (*f*). Poorly built block walls collapsed.

Intensity VIII

Arlight (*r*). Plaster cracked; water in tank spilled; walls slightly cracked. (Cracks in filled-in ground four miles north.)

Arroyo Grande (*f*). A number of chimneys thrown down; walls cracked; all goods thrown from shelves; considerable slumping in sandy Black Lake Road.

Berros (*f* and *r*). Chimney down; walls cracked; plaster cracked.

Betteravia (*f* and *r*). Walls cracked and separated at joints; goods thrown from shelves.

Cambria (*r*). Wall cracked; liquid spilled from open vessel; very little damage to chimneys, etc.

Casmalia (*f*). A chimney thrown down; all goods thrown from shelves and counters; some earth slides on coast road accredited to earthquake.

Cayucos (*r*). Concrete walls cracked.

Concepcion (*r*). Old cracks in walls widened; articles thrown down in lighthouse; rails on track "near-by" thrown out of line.

Guadalupe (*f*). Some plaster fell; adjacent small brick buildings parted slightly; few chimneys fell; articles thrown down; difficult to remain standing out of doors.

Halcyon (*r*). Land slides on sandy road; chimneys down.

Harriston (*r*). Chimney cracked.

Huasno (*r*). Chimney cracked.

Lompoc (*f*). Some chimneys down; walls cracked; cornices down; all articles thrown from shelves.

Los Alamos (*f*). Walls cracked; windows broken; some chimneys down; goods thrown from shelves.

Los Olivos (*r*). Buildings slightly damaged; furniture moved; articles thrown from shelves; liquid splashed from vessels.

Morro Bay (*r*). Chimneys cracked; windows broken; books thrown from shelves.

Nipomo (*f*). Some chimneys down; frame building thrown out of line; plaster cracked; goods thrown from shelves.

Pismo Beach (*f*). Plaster cracked; cracks in sandy ground near by; goods thrown from shelves.

Oceano (*f* and *r*). Chimney cracked; goods thrown from shelves; water spilled from kettles.

San Luis Obispo (*f*). Walls cracked; some chimneys cracked; windows broken; some plaster fell.
San Julian Ranch (*f*). Articles overthrown; slight cracks in adobe walls.
Santa Maria (*f*). A few bricks thrown from cornices; some plaster down; large window broken; some cracks in walls widened.

Intensity VI and VII

Adelaida (*r*). Everyone awakened.
Atascadero (*f*). Few articles thrown over; clocks stopped.
Bakersfield (*r*). Suspended objects swung; pendulum clocks stopped; water spilled from tanks; old crack in old brick wall lengthened; some sleepers awakened.
Bicknell (*r*). Water splashed from pool.
Buellton (*f*). A few articles thrown over.
Buttonwillow (*r*). Pendulum clocks stopped; awakened practically all sleepers.
Carpenteria (*r*). Pendulum clocks stopped; all sleepers awakened; school-bell rung.
Cholame (*r*). Suspended objects swung; all sleepers awakened.
Creston (*r*). Pendulum clocks stopped; suspended objects set in motion; liquid spilled; all sleepers awakened.
Edna (*f*). Jars and glasses thrown over.
Gaviota (*f* and *r*). Sleepers awakened; nothing thrown over; wall clock stopped.
Goleta (*f*). All sleepers awakened.
Harmony (*r*). School-bell rung; quake felt by all.
Kings City (*f*). Most sleepers awakened; window weights banged; electric wires oscillated; some people left houses.
Las Cruces (*f*). Visible agitation of trees; nothing thrown over.
Naples (*f*). Dipper handle broken in tower of pump house; nothing overturned.
Oxnard (*r*). Moved furniture; articles overthrown; cracked wall "reported."
Paso Robles (*f*). All sleepers awakened; few objects overturned; furniture moved; old brick building cracked.
Reward (*r*). All sleepers awakened; water spilled from tanks.
Santa Barbara (*f*). Pendulum clocks stopped; chandeliers swung; "slowness" of motion noted.
Santa Inez (*r*). Pendulum clock stopped; chandeliers swung; felt by all.
Santa Margarita (*f*). Articles thrown over.
Solvang (*r*). Vases rocked; chandeliers swung.
Taft (*r*). Pendulum clocks stopped; suspended objects swung; sleepers awakened; water spilled from tanks.
Tajigua's Store (*f*). Slow motion; nothing thrown down.
Templeton (*f*). Clocks stopped; articles displaced.
Ventura (*r*). Pendulum clocks stopped; sleepers awakened; very old pipe line broken.
Wasioja (*r*). Pendulum clock stopped; objects disturbed.

Intensities IV and V

Annette (*r*). Windows, doors, dishes rattled; suspended objects swung.
Big Surf (*r*). Windows, doors, dishes rattled; some sleepers awakened.
Castroville (*r*). Windows rattled; clocks stopped; not felt by all; awakened some sleepers.
Coalinga (*r*). Windows, doors, dishes rattled; suspended objects swung; sleepers awakened; not felt by all.
Fellows (*r*). Loose objects rattled; suspended objects swung; some sleepers awakened; not felt by all.
Gonzales (*f*). Windows rattled; pyramid of cups in restaurant spread out but did not collapse.
Gorman (*r*). Walls creaked; some sleepers awakened; not felt by all.
Hollister (*r*). Loose objects rattled; walls creaked; some sleepers awakened; not felt by all.
Lockwood (*r*). Walls creaked; pendulum clocks stopped; water in trough disturbed; awakened some sleepers; not felt by all.
Lucia (*r*). Windows, doors rattled; walls creaked; felt by all.
McKittrick (*r*). Windows, doors, dishes rattled; walls creaked; suspended objects swung; not felt by all.
Monterey (*r*). Loose objects rattled; walls creaked; some sleepers awakened; not felt by all.
Parkfield (*r*). Loose objects disturbed.
Pattiway (*r*). Windows, doors, dishes rattled; walls creaked; not felt by all.
Port San Luis (*r*). Felt by all, trucks moved.
Pozo (*r*). Loose objects rattled.
Priest Valley (*r*). Walls creaked.
Salinas (*f* and *r*). Windows rattled; suspended objects swung; some sleepers awakened.
Sanger (*r*). Windows rattled; felt by few.
San Lucas (*r*). Windows, doors, dishes rattled; suspended objects swung; pendulum clock stopped; sleepers awakened; not felt by all.
San Simeon (*r*). A pendulum clock stopped; loose objects rattled; not felt by all.
Santa Paula (*r*). Windows rattled; walls creaked; suspended objects swung; not felt by all.
Scheideck (*r*). Loose objects rattled.
Sespe (*r*). Loose objects rattled.
Simmler (*r*). Windows rattled; suspended objects swung; sleepers awakened; trees shaken slightly; felt by all.
Soledad (*r* and *f*). Suspended objects swung; felt by several.
Tehachapi (*r*). Windows rattled; suspended objects swung; some sleepers awakened.

Intensity I–III

Carmel (*r*). Felt by few; some sleepers awakened.
Fillmore (*r*). "Very slight"; "very many did not notice it."
Fresno (*r*). Felt by few; some sleepers awakened; "frames suspended on long wires swayed slightly."
Gilroy (*f*). Felt by few.
Hanford (*r*). Felt by few.
Kernville (*r*). Felt by few; sleepers awakened.
Los Angeles (*r*). Felt by few; observer lying down reports it felt one-half mile west of Exposition Park.
Los Banos (*r*). Felt by few; pendulum clock stopped; no sleepers awakened.
Morgan Hill (*f*). Felt by very few.
Porterville (*r*). Felt by several.
Redondo Beach (*r*). Stopped several pendulum clocks.
Santa Cruz (*r*). Felt by few; awakened some sleepers; trees shaken slightly.
Tulare (*r*). Felt by a few.
Wheeler Springs (*r*). Felt by very few.
Whittier (*r*). Felt by few.
Yosemite National Park (*r*). Felt by a few.

NOT FELT

Angels Camp (*r*)
Barstow (*r*)
Boulder Creek (*r*)
Coulterville (*r*)
Crows Landing (*r*)
Davis (*r*)
Duarte (*r*)
Hayward (*r*)
Hernandez (*r*)
Isabella (*r*)
Jackson (*r*)
Jerseydale (*r*)
La Panza (*r*)
Lathrop (*r*)
Lodi (*r*)
Long Beach (*r*)
Los Gatos (*r*)
Mariposa (*r*)
Mendota (*r*)
Mojave (*r*)
Monrovia (*r*)
Newman (*r*)
Oakdale (*r*)
Oakland (*r*)
Ontario (*r*)
Orosi (*r*)
Palmdale (*r*)
Palo Alto (*r*)
Pomona (*r*)
Randsburg (*r*)
Reedley (*r*)
Riverside (*r*)
San Bernardino (*r*)
San Diego (*r*)
San Gabriel (*r*)
San Jose (*r*)
San Pedro (*r*)
Santa Ana (*r*)
Selma (*r*)
Sonora (*r*)
Stauffer (*r*)
Stockton (*r*)
Visalia (*r*)
Vicente Light (*r*)
Woodland (*r*)