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SEISMOGRAPHIC STATIONS

No. 13, pp. 273-295 October 29, 1917

THE REGISTRATION OF EARTHQUAKES AT THE BERKELEY STATION

AND

AT THE LICK OBSERVATORY STATION

FROM

OCTOBER 1, 1916, TO MARCH 31, 1917

BY

E. F. DAVIS

UNIVERSITY OF CALIFORNIA PRESS

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CONTENTS

Symbols and Notation

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)	First phase, or first preliminary tremors.
PR_n	Waves n-times reflected at the earth's surface.
S (undae secundae)	Second phase, or second preliminary tremors.
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.
L (undae longae)	Long waves, chief phase, or principal part.
M (undae maximae)	Greatest motion in the chief phase.
C (coda)	Tail or end portion.
F (finis)	End of discernible movement.

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 motion, measured from the median line in microns ($\mu = 1/1000$ mm.).
A_E	E-W component of A.
A_N	N-S component of A.
A_V	Vertical component of A.

4. *Time*—

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

THE BERKELEY STATION

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Latitude and longitude of the center of the seismographic room:

$\phi = 37° 52' 15''.9$ 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

	Period	Magnif.	Damping
Bosch-Omori Seismograph N-S component	15s	80	8–1
Bosch-Omori Seismograph E-W component	15s	80	8–1
Weichert Seismograph Vert. component	6s	80	8–1
Omori Tromometer N-S component	2s	60	-----
Omori Tromometer E-W component	2.5s	60	-----
Marvin Strong-motion Seismograph—			
E-W component	6.5s	5.8	1.3–1
N-S component	6.5s	5.1	1.4–1

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1916			h m s	s	μ	μ	μ	
1	1 Oct.	I_V	e P_{NV}	1 41 19					
			e L_{NV}	1 41 36					
			M_V	1 41 38	1			2	
			M_{EN}	1 41 39	1	2	4		
			C	indefinite					
			F	1 42 54					
2	1 Oct.	I_r?	e	2 43 50					Long flat waves. Barely perceptible trace of a distant earthquake.
			F	3 15 30					
3	3 Oct.	I_u	*O*	*1 26 17*					Δ = 7850 km. Barely perceptible on North-South component. Fair record on vertical component but minute marks are illegible through overscoring.
			e P_E	1 37 32					
			e S_E	1 46 42					
			e L	indefinite					
			M_E	2 07 00	20	5			
			C	indefinite					
			F	3 03 15					
4	3 Oct.	I_{r-u}	e	4 51 19					Barely perceptible on vertical component.
			M_E	4 54 06	11	6			
			M_N	4 55 00	10		4		
			F	5 03 52					
5	11 Oct.	I_V	e	5 50 05					Faint record on vertical component. No definite maximum on East-West component. Felt at Elko, Nevada. *Monthly Weather Review* reports it felt at McDermitt, Nevada.
			M_N	5 52 25	5		4		
			F	5 56 30±					
6	11 Oct.	I_r?	e	18 22 58					Trace of a distant earthquake on all components.
			M_{EN}	18 26 19	7	6	4		
			F	18 52±					
7	20 Oct.	I_u	*O*	*17 04 46*					Δ = 8060 km. Beginning of chief phase not discernible. Main phase consists of a series of vibrations of long period and small amplitude. No definite maximum.
			e P	17 16 10					
			e S	17 25 33					
			F	19 16±					
8	23 Oct.	I_V	e	2 44 16					Origin near Tejon Pass. Felt generally throughout Southern California and South end of the Great Valley. Marvin seismograph started by repeated undulations of ground. F interrupted by beginning of following shock.
			M_N	2 46 02	5		10		
			M_E	2 46 18	3	7			
			M_V	2 46 31	3			6	
			F	2 54 32					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1916			h m s	s	μ	μ	μ	
9	23 Oct.	I_V	e	2 54 32					Origin near Tejon Pass. Felt in Southern California and South end of Great Valley. Records show a series of irregular, weak vibrations without definite maximum.
			F	3 00±					
10	23 Oct.	I_u	e P	7 40 38					Felt at Rio Vista and Martinez. Records show a strong thickening of pen traces.
			e L	indefinite					
			F	7 41 10					
11	23 Oct.	I_u	i P_N	18 57 19.2					Felt at Rio Vista, Martinez, Lodi, Stockton, and Oakland. Vertical record consists of a strong thickening of the pen trace.
			i P_E	18 57 19.3					
			i LM_{EN}	18 57 24.5	½	14	19		
			C	18 57 30					
			F	18 59 20					
12	24 Oct.	I_V	e	13 31 14					Trace of a near earthquake. Series of weak, irregular waves in which no phases or maxima are discernible. See No. 12 in list of Lick Observatory.
			F	13 33 50					
13	31 Oct.	I_{r-u}	e	15 43 20					Series of simple sinusoidal waves from $15^h 58^m 35^s$ to $15^h 03^m 00^s$ with period and amplitudes given opposite M.
			M		22	6	3		
			F	16 51+					
14	3 Nov.	I_V	e	10 04 36					Series of very minute vibrations on horizontal components. *Monthly Weather Review* reports an earthquake felt at Los Gatos and Santa Cruz at $10^h 05^m$.
			F	10 04 48					
15	10 Nov.	I_V	e P_E	9 13 21.0					See discussion in text.
			e P_N	9 13 21.7					
			e S_N	9 14 02.4					
			e L_E	9 14 30.3					
			e L_N	9 14 30.8					
			M_{N_1}	9 15 05	9		167		
			M_E	9 15 45	7	161			
			M_{N_2}	9 15 55	7		171		
			C	9 16 57					
			F	9 39±					
16	10 Nov.	I_V	e	12 27 30					Trace of a near shock. Records show a series of weak, irregular waves.
			F	12 29 12					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1916			h m s	s	μ	μ	μ	
17	11 Nov.	I_r?	e	13 54 04					Trace of a distant earthquake. Sinusoidal waves from 14h 00m 04s to 14h 15m 14s. Not registered on vertical.
			M		18	2	3		
			F	14 30±					
18	11 Noc.	I_r?	e	15 38 04					Trace of a distant earthquake. Sinusoidal waves from 15h 47m 04s to 16h 05m 54s.
			M		19	2	2		
			F	16 17±					
19	15 Nov.	I_V	e	14 22 58					Trace of a near shock. A series of weak, irregular waves in which no phases and no definite maxima are apparent. Visible on East-West component only.
			F	14 25 28					
20	18 Nov.	I_{r-u}	e	12 04±					Beginning and ending obscured by unusually strong microseisms. Barely perceptible on East-West and vertical components.
			M_N	12 10 33	20		3		
			F	12 15±					
21	19 Nov.	I_V	e	20 54 03					Series of irregular vibrations on East-West record. North-South instrument undergoing repairs.
			M_E	20 55 09	6	5			
			F	20 58 53					
22	21 Nov.	I_r	*O*	*6 25 09*					Δ = 3720 km. Microseisms interfere with accurate reading of the seismogram. Vertical seismograph undergoing repairs.
			e P_E	6 32 06					
			e S_{EN}	6 37 37					
			e L_E	6 41 12					
			e L_N	6 41 24					
			M_E	6 42 48	25	30			
			M_N	6 46 28	13		60		
			F	7 30±					
23	28 Nov.	I_V	e	7 03 48					Series of very weak, irregular vibrations. Strongest on North-South, barely perceptible on East-West and not visible on vertical component. See discussion in text.
			F	7 05 46					
24	28 Nov.	I_V	e	7 06 37					Barely perceptible irregular vibrations. Trace of a near shock. Not registered by vertical seismograph. See discussion in text.
			F	7 08 01					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1916			h m s	s	μ	μ	μ	
25	28 Nov.	I_V	e	7 29 54					Series of weak, irregular vibrations. See discussion in text.
			F	7 31 41					
26	30 Nov.	I_u?	e	3 45±					Trace of a distant earthquake distinctly visible on all components. The phases of the seismograms are masked by exceptionally strong microseisms.
			F	4 06±					
27	1 Dec.	I_V	e	22 53 43					Beginning and ending obscured by strong microseisms. Not registered by vertical seismograph. *Four* earthquakes reported at San Luis Obispo at 22h 50m. They were apparently most severe along the coast. There was a disturbance in the water of San Luis Obispo Bay.
			e L_N	22 54 27					
			e L_E	22 54 28					
			M_E	22 54 39	3½	8			
			M_N	22 54 59	6		13		
			F	22 58 45					
28	2 Dec.	I_{r-u}	e	12 46 06					Barely perceptible long flat waves on all three components.
			F	13 11 30±					
29	14 Dec.	I_r	e	17 10 54					Barely perceptible on East-West component. Not registered by vertical seismograph.
			M_N	17 16 49					
			F	17 35±					
	1917								
30	16 Jan.	I_V	e_N	13 15 09					Very weak on East-West component.
			M_N	13 15 35	5		4		
			F	13 20 49					
31	30 Jan.	III_u	*O*	*2 45 29*					Δ = 5720 km. East-West seismograph out of order. See discussion in text.
			e P_V	2 54 43					
			e P_N	2 54 44					
			e S_N	3 02 05					
			e S_V	3 02 15					
			e L_N	3 07 32					
			e L_V	3 07 58					
			M_N	3 08 02	26		235		
			M_V	3 15 00	20			41	
			C	indefinite					
			F	6 41±					
32	31 Jan.	I_{r-u}	e	3 45±					Trace of a distant earthquake. Beginning and ending obscured by microseisms.
			M_E	3 49 17	25	2			
			M_N	3 50 57	25		2		
			F	4 46±					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1917			h m s	s	μ	μ	μ	
33	9 Feb.	I_V		15 26±					A weak near shock is apparent on all three components. The exact time is not certain because the break circuit chronometer was out for repairs on this day. Mr. Palmer of the San Francisco Weather Bureau reports an earthquake felt at San Jose at $15^h 28^m$.
34	13 Feb.	I_r	e	3 40±					Trace of a distant earthquake on horizontal components.
			F	3 52±					
35	15 Feb.	I_u	e	1 30±					Barely perceptible trace of a distant earthquake on horizontal components.
			F	2 00±					
36	18 Feb.	I_r?	e	15 33±					Trace of a distant earthquake. Very faint on vertical component.
			M_E	15 41 04	8	4			
			M_N	15 44 50	4		4		
			F	16 10±					
37	20 Feb.	I_r	*O*	*19 29 41*					Δ = 4660 km.
			e P_{EV}	19 37 46					
			e P_S	19 37 48					
			e S_N	19 44 07					
			e S_V	19 44 09					
			i S_E	19 44 12					
			e L_E?	19 55 47					
			e L_S?	19 56 14					
			M_N	19 57 12	14½		238		
			M_E	19 59 12	14	81			
			M_V	19 59 38	11			12	
			C	indefinite					
			F	21 10±					
38	6 Mar.	I_r	*O*	*3 05 38*					Δ = 3660 km. North-South instrument out of order.
			e P_E	3 12 31					
			e P_V	3 12 45					
			e S_E	3 17 58					
			e S_V	3 18 05					
			e L_E	3 22 32					
			M_E	3 28 40	10	13			
			M_V	3 30 04	9½			4	
			C	indefinite					
			F	3 55±					
39	13 Mar.	I_V	e P_N	15 04 17					Not registered by vertical seismograph.
			e P_E	15 04 18					
			e L_E?	15 04 32					
			M_N	15 04 34	1½		2		
			M_E	15 04 36	1¾	2			
			F	15 06 20±					
40	15 Mar.	I_{r-u}	e	0 33±					Barely perceptible trace of a distant earthquake.
			F	1 05±					

THE LICK OBSERVATORY STATION

CONSTANTS

Constants of the Station

Latitude and longitude of the center of the seismographic room:

$\phi = 37° 20' 24''.5$ 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

	Period	Magnif.	Damping
Wiechert Seismograph N-S component	8.0	80	4:1
Wiechert Seismograph E-W component	7.0	80	5:1
Wiechert Seismograph Vertical component	2.5	80	2:1

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1916			h m s	s	μ	μ	μ	
1	13 Oct.	I_d	e	16 23 12					Thickening of pen trace on vertical record. Not registered on East-West component.
			M_N	16 23 18	½		5		
			F	16 23 26					
2	13 Oct.	I_d	e	21 56 50					Thickening of pen traces on North-South and vertical records.
			F	21 56 57					
3	17 Oct.	I_d	i P_N	15 34 53.8					Not visible on East-West component. A thickening of pen trace on vertical record.
			i LM_N	15 34 56.5	½		9		
			C	15 34 59					
			F	15 35 03					
4	17 Oct.	I_d	e	15 38 48					Thickening of pen trace. North-South component only.
			F	15 38 51					
5	18 Oct.	I_d	i P_N	0 39 28.6					Thickening of pen traces on East-West and vertical records.
			i LM_N	0 39 32.1	½		11		
			C	indefinite					
			F	0 39 40					
6	19 Oct.	I_d	e	0 54 16					Thickening of pen traces on East-West and vertical records.
			M_N	0 54 20	½		5		
			F	0 54 26					
7	20 Oct.	I_u	*O*	*17 05 07*					Δ = 7820 km. North-South component only. Beginning of chief phase not well defined. The chief phase consists of a series of long flat waves in which no maximum is apparent.
			e P	17 16 18					
			e S	17 25 29					
			F	19 15±					
8	23 Oct.	I_v	e	2 44 44					Faint trace on vertical. F is interrupted by the beginning of the next earthquake. See No. 8 in Berkeley list.
			M_E	2 45 32	2	28			
			M_N	2 45 44	4		42		
			F	2 53 44+					
9	23 Oct.	I_v	e	2 53 44					Series of weak irregular vibrations. Not registered by vertical seismograph. See No. 9 in Berkeley list.
			M_{EN}	2 54 53	1	4	5		
			F	2 58 39					
10	23 Oct.	I_v	e	7 40 56					A series of very minute short period vibrations producing a thickening of pen traces. Horizontal components only. See No. 10 in Berkeley list.
			F	7 41 24					

No.	Date	Charac.	Phase	Time G. M. C. T	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1916			h m s	s	μ	μ	μ	
11	23 Oct.	I_d	e	18 57 26					Series of very minute vibrations on vertical record.
			M_N	18 57 34	½		5		
			M_E	18 57 36	¾	6			
			F	18 59 01					
12	24 Oct.	I_v	e P	13 30 50					Series of irregular vibrations of small amplitude on East-West component. Not registered by vertical seismograph. *Monthly Weather Review* reports an earthquake felt at King City, Lonoak, and San Luis Obispo at $13^h\ 03^m$. It was not registered either at the Lick Observatory or at Berkeley. See No. 12 in Berkeley list.
			i LM_N	13 31 04	½		15		
			C	indefinite					
			F	13 32 13					
13	24 Oct.	I_d	e	19 54 54					North-South component only.
			M_N	19 54 58	½		5		
			F	19 55 01					
14	24 Oct.	I_d	e	20 10 55					Thickening of pen trace on East-West. Not registered by vertical seismograph.
			M_N	20 10 58	½		5		
			F	20 11 02					
15	28 Oct.	I_d	e P_N	1 35 55.5					Strong thickening of pen traces on East-West and vertical components.
			e L_N	1 35 59.5					
			M_N	1 36 02	½		11		
			C	1 36 04					
			F	1 36 08					
16	28 Oct.	I_d	e	1 36 52					Strong thickening of pen traces on North-South component only.
			F	1 37 05					
17	30 Oct.	I_d	e	16 39 19					Registered on East-West and vertical components by a thickening of the pen traces.
			M_N	16 39 25	½		9		
			F	16 39 31					
18	1 Nov.	I_d	e	0 44 20					Registered on East-West and on vertical by a thickening of pen traces.
			M_N	0 44 30	½		11		
			F	0 44 36					
19	1 Nov.	I_d	e	0 55 11					North-South only. A strong thickening of pen trace.
			F	0 55 19					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1916			h m s	s	μ	μ	μ	
20	2 Nov.	I_d	e	1 13 47					Registered on East-West and vertical components by a thickening of the pen traces.
			M_N	1 13 51	½		10		
			F	1 13 57					
21	2 Nov.	I_d	e	1 17 52					Registered on East-West and vertical components by a thickening of the pen traces.
			M_N	1 17 57	½		10		
			F	1 18 01					
22	2 Nov.	I_d	e	1 19 58					North-South component only. A strong thickening of the pen trace.
			F	1 20 04					
23	3 Nov.	I_d	e P	10 04 19.5					Registered on vertical component by a thickening of pen trace. See No. 14 in Berkeley list.
			i LM	10 04 24.0	½	14	9		
			C	10 04 17					
			F	10 04 33					
24	9 Nov.	I_d	e	16 17 20					Thickening of pen traces. Horizontal components only.
			F	16 17 32					
25	10 Nov.	I_v	e P_N	9 13 15					Origin in Nevada. See discussion in text.
			e P_E	9 13 21					
			e S_E	9 13 57					
			e S_N	9 13 58					
			i L_N	9 14 21					
			e L_E	9 14 22					
			M_V	9 14 33	4			47	
			M_N	9 15 12	7		295		
			M_E	9 15 24	7	251			
			C	9 20 39					
			F	9 38±					
26	10 Nov.	I_v	e	12 27 00					A series of weak, irregular vibrations. Horizontal components only.
			M_{EN}	12 27 43	1	3	2		
			F	12 29 24					
27	11 Nov.	I_v?	e	13 51±					North-South component only. Sinusoidal waves from $14^h\ 01^m\ 58^s$ to $14^h\ 10^m\ 53^s$ with period and amplitude given opposite M.
			M		19		1		
			F	14 23±					
28	11 Nov.	I_v?	e	15 43±					North-South component only. Sinusoidal waves rrom $15^h\ 48^m\ 23^s$ to $16^h\ 00^m\ 03^s$ with period and amplitude given opposite M.
			M		13		1		
			F	16 20±					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1916			h m s	s	μ	μ	μ	
29	13 Nov.	I_d	e	21 28 14					Registered on East-West component by a thickening of pen trace. Not registered by vertical seismograph.
			M_N	21 28 22	½		4		
			F	21 28 27					
30	15 Nov.	I_v	e P	14 22 44					Very weak on East-West component due to friction of pen. Not registered by vertical seismograph.
			e L	14 23 33					
			M_N	14 23 44	2		6		
			C	14 23 54					
			F	14 26 19					
31	16 Nov.	I_d	e	20 48 17					Registered on vertical component by a thickening of pen trace. East-West pen shifted off paper due to defect in adjustment.
			M_N	20 48 21	½		4		
			F	20 48 28					
32	17 Nov.	I_d	e P	17 57 33					Registered on East-West and vertical components by a thickening of pen traces.
			i LM_N	17 57 36	½		7		
			C	indefinite					
			F	17 57 41					
33	17 Nov.	I_d	e	19 11 18					Registered on East-West and vertical components by a strong thickening of pen traces.
			M_N	19 11 24	½		6		
			F	19 11 29					
34	17 Nov.	I_d	e	21 16 03					Registered on East-West and vertical components by a strong thickening of pen traces.
			M_N	21 16 08	½		5		
			F	21 16 14					
35	18 Nov.	I_d	e	0 28 20					Registered on East-West and vertical components by a strong thickening of pen traces.
			M_N	0 28 26	½		5		
			F	0 28 30					
36	19 Nov.	I_v	e	20 54 38					Series of weak, irregular waves. Not registered by vertical seismograph.
			M_{EN}	20 55 03	1½	3	3		
			F	20 55 59					
37	28 Nov.	I_d	e P	7 03 37					Not registered by vertical seismograph. See discussion in text.
			e L	7 03 47					
			M_{EN}	7 03 55	1	7	6		
			C	indefinite					
			F	7 05 35					
38	28 Nov.	I_d	e P	7 06 27					e L somewhat confused by minute mark. M_E unmeasurable because of confusion with mark. Not registered by vertical seismograph. See discussion in text.
			e LM	7 06 37	1		10		
			C	indefinite					
			F	7 07 56					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1916			h m s	s	μ	μ	μ	
39	28 Nov.	I_d	e	7 08 36					Strong thickening of pen traces. Not registered by vertical seismograph. See discussion in text.
			F	7 09 46					
40	28 Nov.	I_d	e P	7 29 44					Strong thickening of pen trace on East-West. Not registered by vertical seismograph. See discussion in text.
			e L	7 29 54					
			M_N	7 30 05	1		5		
			C	indefinite					
			F	7 30 16					
41	1 Dec.	I_V	e P_N	22 53 30					Exact time somewhat uncertain as no clock correction is available for this day. East-West component not in adjustment. Shock not registered by vertical seismograph. Origin near San Luis Obispo. See No. 27 in list of Berkeley Station.
			e L_N	22 54 10					
			M_N	22 54 21	3		21		
			C	22 54 55					
			F	23 00 11					
42	8 Dec.	I_d	e P	0 43 57					Registered on East-West and on vertical components by a strong thickening of pen traces.
			i LM	0 43 59	½		11		
			C	indefinite					
			F	0 44 05					
43	8 Dec.	I_d	i P	1 12 21					Registered on East-West and vertical components by a strong thicking of pen traces.
			i LM_N	1 12 25	½		16		
			C	1 12 29					
			F	1 12 32					
44	12 Dec.	I_d	e	17 04 24					North-South component only. Strong thickening of pen trace.
			F	17 04 27					
45	12 Dec.	I_d	e	23 35 24					North-South component only. Strong thickening of pen trace.
			F	23 35 29					
46	13 Dec.	I_d	i P	0 28 29					Registered on East-West component by a strong thickening of pen trace. Not registered by vertical seismograph.
			i LM	0 28 31	½		5		
			C	0 28 32					
			F	0 28 34					
47	13 Dec.	I_d	e	17 59 21					Successive pen strokes are so close together that smoke is entirely removed, giving an etxra strong thickening of pen trace. Weak on East-West and vertical components.
			M_N	17 59 26	½		6		
			F	17 59 38					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1916			h m s	s	μ	μ	μ	
48	14 Dec	I_d	e P	0 37 40.5					Registered on East-West and vertical components by a slight thickening of pen traces.
			i L	0 37 44.5					
			M	0 37 58	½		10		
			C	indefinite					
			F	0 37 11					
49	14 Dec.	I_d	e P	16 55 34					Registered on East-West component by a strong thickening of pen trace. Barely perceptible on vertical component.
			e LM	16 55 37	½		9		
			C	indefinite					
			F	16 55 46					
50	14 Dec.	I_d	e P	17 52 19.0					Slight disturbance of pens on East-West and vertical components.
			i L	17 52 23.5					
			M	17 52 25	½		11		
			C	indefinite					
			F	17 52 34					
51	14 Dec.	I_d	e	18 45 11					Strong thickening of pen traces on all components. Strongest on North-South record.
			F	18 45 23					
52	14 Dec.	I_d	e	19 40 23					Very strong thickening of pen trace on North-South component. Weak on East-West and vertical components.
			F	19 40 32					
53	15 Dec.	I_d	e	0 33 12					Strong thickening of pen trace on North-South component. Weak on East-West component. Not registered by vertical seismograph.
			F	0 33 18					
54	15 Dec.	I_d	e P	17 25 11					Registered on East-West and vertical components by a strong thickening of pen traces.
			e L	17 25 16					
			M_{N1}	17 25 18	½		10		
			M_{N2}	17 25 21	½		12		
			C	17 25 22					
			F	17 25 26					
55	18 Dec.	I_d	i P	7 06 06.0					
			i LM	7 06 08.5	½	10	9	3	
			C	7 06 11					
			F	7 06 24					
56	18 Dec.	I_d	e P	19 44 52					Registered on East-West and vertical components by a strong thickening of pen traces.
			e L	19 44 57					
			M_N	19 45 00	½		13		
			C	19 45 05					
			F	19 45 08					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1916			h m s	s	μ	μ	μ	
57	19 Dec.	I_d	e	22 59 46					Strong thickening of pen trace on North-South component. Weak on East-West component. Vertical record rendered illegible through overscoring.
			F	22 59 56					
58	19 Dec.	I_d	e P	23 12 59.0					Registered on East-West component by a thickening of pen trace. Vertical record illegible through overscoring.
			e L	23 13 01.5					
			M	23 13 00	½		11		
			C	indefinite					
			F	23 13 08					
59	19 Dec.	I_d	e	23 18 27					Amplitudes gradually increase up to a maximum, after which they gradually decrease. Thickening of pen trace on East-West component. Vertical record illegible through overscoring.
			M	23 18 33	½		8		
			F	23 18 39					
60	26 Dec.	II_d	i P	5 16 18.0					
			i LM	5 16 19.2	½	15	28	5	
			C	5 16 21					
			F	5 16 38					
61	30 Dec.	I_d	i P	5 58 04.6					Registered on vertical component by a thickening of the pen trace.
			i LM	5 58 05.8	½	14	14		
			C	5 58 10					
			F	5 58 33					
	1917								
62	12 Jan.	I_d	e P	19 49 14					Registered on vertical component by a thickening of the pen trace.
			e L	19 49 26					
			M	19 49 28	½	9	6		
			C	indefinite					
			F	19 51 08					
63	18 Jan.	I_d	i P	4 17 13.6					
			i LM	4 17 14.8	½	14	15	4	
			C	4 17 20					
			F	4 17 31					
64	25 Jan.	I_d	e	0 49 14					Strong thickening of pen traces on all components.
			F	0 50 20					
65	30 Jan.	I_d	*O*	*2 45 21*					Δ = 5900 km. See discussion in text.
			e P_N	2 54 45					
			e S_N	3 02 16					
			e L_N	3 07 30					
			M_N	3 12 21	13		73		
			C	3 27 42					
			F	4 20±					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1917			h m s	s	μ	μ	μ	
66	3 Feb.	I_d	e	0 29 50					Thickening of pen traces on all components.
			F	0 30 00					
67	3 Feb.	I_d	e	0 54 22					Strong thickening of pen traces on all components.
			F	0 54 31					
68	9 Feb.	III_d	i P	15 26 54.5					Greater part of North-South record is illegible because of the chattering of the pen traces. Mr. A. H. Palmer of the San Francisco Weather Bureau reports it felt in San Jose. It was reported as "light" by the observer there.
			i LM	15 26 56.3	½	210	?	26	
			C	15 27 03					
			F	15 27 54					
69	15 Feb.	I_d	e	0 27 16					Strong thickening of pen traces on all components.
			F	0 27 27					
70	16 Feb.	I_d	e	0 14 41					Strong thickening of pen traces on all components. Strongest on North-South component, where there is a definite maximum.
			M_N	0 14 46	½		5		
			F	0 14 48					
71	16 Feb.	I_d	e	0 22 44					Strong thickening of pen traces on all components.
			F	0 22 53					
72	20 Feb.	I_r	*O*	*19 29 20*					Δ=4960 km.? e L_N? marks beginning of regular waves. East-West component not legible. Not registered by vertical seismograph.
			e P_N	19 37 45					
			e S_N?	19 44 31					
			e L_N?	19 55 08					
			M_N	19 55 47	12		93		
			C	indefinite					
			F	12 55±					
73	27 Feb.	I_d	e	0 37 29					Thickening of pen traces on all components.
			F	0 37 37					
74	27 Feb.	I_d	e	0 51 51					Thickening of pen traces on all components.
			F	0 51 59					
75	6 Mar.	I_r	e P_N	3 12 27					Barely perceptible trace on East-West component. Not registered by vertical seismograph.
			e L_N	3 22 02					
			M_N	3 28 07	8		6		
			C	indefinite					
			F	3 58±					

No.	Date	Charac.	Phase	Time G.M.C.T.	Period	Amplitude A_E	Amplitude A_N	Amplitude A_V	Remarks
	1917			h m s	s	μ	μ	μ	
76	13 Mar.	I_d	e P	15 04 05					Registered on vertical component by a thickening and displacement of the pen trace. The Weather Bureau reports an earthquake felt at Salinas at $15^h\,15^m$.
			e L	15 04 13					
			M_E	15 04 17	1½	5			
			M_N	15 04 25	2		9		
			C	indefinite					
			F	15 05 40					
77	15 Mar.	I_{r-a}	e	0 34 43					Barely perceptible trace of a distant earthquake on horizontal components only.
			F	1 02±					
78	23 Mar.	I_d	e	1 17 31					Strong thickening of pen traces on all three components.
			F	1 17 48					
79	23 Mar.	I_d	i P	18 35 34					A series of very minute vibrations appears on the vertical.
			i LM	18 35 36	½	11	15		
			C	18 35 38					
			F	18 35 43					
80	27 Mar.	I_d	e	19 08 13					Not registered by vertical. Weak on East-West component.
			M_N	19 08 20	½		8		
			C	19 08 23					
			F	19 08 33					
81	27 Mar.	I_d	e	19 13 36					Strong thickening of pen traces on horizontal components only.
			F	19 13 43					
82	29 Mar.	I_d	e	23 39 54					Strong thickening of pen traces on all components.
			F	23 40 01					
83	30 Mar.	I_d	e	6 27 44					Thickening of pen traces on horizontal components only.
			F	6 27 49					
84	30 Mar.	I_d	e	16 56 55					Strong thickening of pen traces on horizontal components.
			F	16 57 03					
85	31 Mar.	I_d	i P	23 46 52					
			i LM	23 46 54	½	6	11	2	
			C	23 46 57					
			F	23 46 59					

DISCUSSION OF PARTICULAR SHOCKS

Nevada Earthquake of November 10, 1916

At Berkeley, excellent records were written by the two horizontal-component Bosch-Omori seismographs. The vertical instrument was out of order and undergoing repairs. The shock was registered by both components of the Omori tromometer, but the intensity was not quite great enough to operate the starting device on the Marvin strong-motion seismograph. Excellent horizontal records were obtained at the Lick Observatory. The vertical record from that station is poor and shows the effect of excessive friction.

The seismograms from Lick Observatory and Berkeley are similar in their peculiarities. At both stations the East-West components show two groups of waves in the chief phase. The waves of the first group are of moderate amplitude; increase gradually to a maximum and die away gradually. These are followed by a second similar group of waves of much larger amplitude. After this no more important vibrations occur. The records of the North-South components at both Lick Observatory and Berkeley show at least four well-defined groups of waves in the chief phase.

The *Monthly Weather Review* reports an earthquake felt at Las Vegas and Rhyolite in Nevada at $9^h\,13^m$. The intensity of the earthquake at Rhyolite was IV of the Rossi-Forel scale; at Las Vegas it was III.

The seismograms at the California stations indicate that the intensity at the point of origin was much higher than this, thus showing that the origin was not close to either of the two places named.

Group of Local Earthquakes of November 28, 1916

This group of shocks was composed of four weak earthquakes occurring within half an hour.

At Berkeley, the seismograms of these earthquakes each consist of a series of very weak irregular waves in which no phases are discernible. The third member of the group, which was the weakest, is not certainly registered at this station. There is movement at the time when the disturbance should be found, but it is not certain whether this is due to an earthquake or is a weak microseismic movement. Microseisms are seen in many places on the record for this day.

At the Lick Observatory, which lies closer to the point of origin, better records are available, and on these the phases can be determined. The duration of the preliminary tremors (L–P) is nearly ten seconds. The epicentral distance calculated by Omori's formula, is 77 kilometers.

On account of the weakness of the records, it is not possible to determine the epicentral distance at the Berkeley station, so the position of the origin cannot be determined instrumentally.

The *Monthly Weather Review* reports three earthquakes at Spreckels at $7^h\,11^m$. The distance from Spreckels to Mount Hamilton is 80 kilometers. The last earthquake in the group is not reported felt at Spreckels, but its seismogram is very similar to those of the first three earthquakes. The epicentral distance is the same as the other and it is probable that it had the same origin.

In view of the epicentral distance determined at Mount Hamilton, and the fact that the shocks were reported only from Spreckels, it appears that these earthquakes were due to displacements on the fault zone that runs down the valley of the Salinas River.

Teleseism of January 30, 1917

At Berkeley, excellent records were written on the North-South Bosch-Omori seismograph and on the Wiechert vertical seismograph. The registration by the East-West component instrument was not satisfactory because of the binding of the damping device. The first and second phases of the seismogram begin gradually, but distinctly, so that an accurate determination of the time of beginning is possible. The chief phase of the

seismogram shows a notable grouping of vibrations. In each group the amplitude is first small, then gradually increases to a maximum, after which it decreases gradually.

At the Lick Observatory, an excellent seismogram was obtained on the North-South component. The East-West component is imperfect because of a defect in adjustment. The earthquake was not registered by the vertical seismograph. The seismograms at the Lick Observatory show the same tendency to grouping of waves that is noticed on the Berkeley records.

On the basis of a comparison of seismograms obtained at Ottawa, Harvard, Spring Hill, Berkeley, and Georgetown, Klotz* has determined the epicenter of this earthquake to be in the peninsula of Kamchatka. ($\phi = 57°\ 00'$ N. $\lambda = 160°\ 10'$ E.)

* Bull. Seis. Soc. Am., 7 (1917), p. 34.