UNIVERSITY OF CALIFORNIA PUBLICATIONS

BULLETIN OF THE

SEISMOGRAPHIC STATIONS

No. 12, pp. 243-271 April 17, 1917

THE REGISTRATION OF EARTHQUAKES AT THE BERKELEY STATION

AND

AT THE LICK OBSERVATORY STATION

FROM

APRIL 1, 1916, TO SEPTEMBER 30, 1916

BY

E. F. DAVIS

UNIVERSITY OF CALIFORNIA PRESS
BERKELEY

UNIVERSITY OF CALIFORNIA PUBLICATIONS

BULLETIN OF THE

SEISMOGRAPHIC STATIONS

No. 12, pp. 243-271 April 17, 1917

THE REGISTRATION OF EARTHQUAKES AT THE BERKELEY STATION

AND

AT THE LICK OBSERVATORY STATION

FROM

APRIL 1, 1916, TO SEPTEMBER 30, 1916

BY

E. F. DAVIS

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

CONSTANTS

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	2 Apr.	I_r	*O?*	*8 22 00*					Not registered by the vertical seismograph. Δ = 1380 km.
			e P_{EN}	8 25 13					
			e L_E	8 29 10					
			e L_N	8 29 25					
			M_N	8 30 17	7		2		
			M_E	8 30 34	9	4			
			F	8 48±					
2	2 Apr.	I?	e	19 02 36					East-West component only. Long, flat, barely perceptible waves. Trace of a distant earthquake.
			F	19 14 16					
3	6 Apr.	I_v	e P_N	19 02 17					
			e P_E	19 02 19					
			e P_V	19 02 21					
			e S_N	19 02 46					
			e L_N	19 04 13					
			M_E	19 04 17	10	20			
			M_V	19 04 41	10			7	
			M_N	19 04 47	9½		10		
			F	19 18 59					
4	6 Apr.	I_r	e	20 34 49					Series of irregular waves of short period and small amplitude; the trace of a near shock. The first minute of the record shows waves 1-1½ microns in amplitude with a period of 1 second. These gradually merge into the latter portion, where periods are on the average about 4 seconds and the amplitudes range up to 4 microns.
			F	20 45 44					
5	7 Apr.	I_r	e	8 35 54					Trace of a near shock. No phases discernible. Not registered on vertical component.
			F	8 42 29					
6	7 Apr.	I_u	*O?*	*9 33 29*					Δ = 12,000 km. See discussion in text.
			e P_N?	9 46 23					
			e S_N	9 58 48					
			e S_E	9 58 54					
			e L	indefinite					
			F	11 43±					
7	14 Apr.	I?	e	20 42 05					Trace of the chief phase of a distant earthquake. Registered on East-West component only.
			F	20 55±					
8	16 Apr.	I?	e	22 39 07					Trace of a distant earthquake on horizontal components but very faint on North-South component.
			F	23 12±					
9	18 Apr.	I_r	*O*	*4 01 44*					Δ = 3620 km. Some of the shifts of the pen during the second preliminaries on the East-West component are nearly as great as the maximum on that component. No trace of movement on vertical record.
			i P_E	4 08 39					
			i P_N	4 08 40					
			i S_N	4 14 13					
			i S_E	4 14 17					
			e L_{EN}?	4 16 58					
			M_{EN}	4 18 45	8½	37	11		
			C	indefinite					
			F	5 18±					
10	21 Apr.	I_u	*O*	*11 31 51*					Δ = 8400 km. No definite maximum on North-South component. Main phase very weak on both horizontal components. Not registered by vertical seismograph.
			e P_E	11 43 31					
			e P_N	11 43 33					
			e S_N	11 53 08					
			e S_E	11 53 09					
			e L_E?	12 06 25					
			M_E	12 09 51	19	4			
			F	13 28±					
11	24 Apr.	I_u	*O*	*4 26 36*					Δ = 5450 km. A few vibrations visible on vertical record. See discussion in text.
			e P_N	4 35 33					
			e P_E?	4 35 56					
			i S_N	4 42 40					
			e S_E	4 42 53					
			F	5 33±					
12	24 Apr.	I_u	*O*	*8 01 44*					Δ = 5100 km. Registered by vertical seismograph but the seismogram is rendered illegible by overscoring. Amplitudes on North-South component are always smaller than amplitudes on East-West component for all parts of the record.
			i P_E	8 10 19					
			e P_N	8 10 23					
			e S_N	8 17 03					
			e S_E	8 17 08					
			e L_E	8 23 08					
			M_N	8 30 28	19		4		
			M_E	8 30 36	27	34			
			C	8 43 30					
			F	9 41±					

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	
13	26 Apr.	I_u	*O*	*2 21 15*					Δ = 5050 km. Not registered by vertical seismograph.
			i P_{EN}	2 29 23					
			e S_N	2 36 24					
			e S_E	2 36 25					
			e L_{EN}	2 42 04					
			M_E	2 48 26	20	8			
			M_N	2 52 30	19		6		
			C	2 58 09					
			F	3 43±					
14	26 Apr.	I?	e	6 41±					Long, flat, barely perceptible waves on horizontal components only. Trace of a distant earthquake.
			F	7 50±					
15	10 May	I?	e P	21 45 10					Barely perceptible record of a distant earthquake on horizontal components. Phases not discernible.
			F	22 23 15					
16	11 May	I_r	e	7 50 40					Small irregular waves on horizontal components representing the trace of a near shock. Record somewhat confused by microseisms.
			F	7 53 25					
17	11 May	I_{r-u}	e	10 08 31					Trace of chief phase of a distant earthquake on horizontal components.
			M_E	10 15 09	13	5			
			M_N	10 16 12	9		7		
			F	10 38±					
18	13 May	I_r	e	2 31 30					Beginning obscured by strong microseisms. No phases discernible. Trace of a near earthquake with origin in Idaho.
			M_N	2 32 21	4½		5		
			M_E	2 32 33	3	3			
			M_V	2 32 43	3½			2	
			F	2 38±					
19	2 June	I_r?	e	14 05 30±					Barely perceptible trace of a distant earthquake. Horizontal components only.
			F	14 35 30±					
20	19 June	I?	e	1 29 40±					Barely perceptible trace of a distant earthquake. Horizontal components only.
			F	1 48 40±					

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	
21	21 June	I_u	e_N	9 46 10					No maximum in main phase on North-South component. Maximum comes during second preliminaries. No definite maximum on East-West seismogram.
			e S_E	9 46 21					
			e S_N	9 53 54					
			M_N	9 54 07	9		14		
			F	10 24±					
22	24 June	I_r	e	7 04 57					Trace of a distant earthquake? There were moderate microseisms running on this day and it is possible that this disturbance may be an isolated group of unusually strong microseisms. This latter interpretation is improbable. Recorded on horizontal components only.
			F	7 11±					
23	24 June	I_r?	e	18 22 53					Sinusoidal waves from $18^h 30^m$ to $18^h 35^m 20^s$; average periods 17 to 18 seconds. Amplitudes 11μ on North-South and 4μ on East-West component.
			F	18 43±					
24	27 June	I_r	e P_N	13 43 25					Registered by both components of Omori tromometer. Barely perceptible disturbance on vertical record. *Monthly Weather Review* reports shocks at $13^h 45^m$ at King City, Lonoak, Salinas, and Santa Cruz.
			e P_E	13 43 31					
			e L_N	13 43 46					
			e L_E	13 43 52					
			M_N	13 44 04	1½		17		
			M_E	13 44 12	2	9			
			C	13 44 36					
			F	13 48 16					
25	27 June	I_u	e P_E	14 15 43.6					See discussion in text.
			e P_N	14 15 43.7					
			e L_N	14 15 52.0					
			e L_E	14 15 52.4					
			M_N	14 15 54	1		6		
			M_E	14 15 55	1	6			
			C	indefinite					
			F	14 18 06					
26	30 June	I_u	*O*	*3 00 45*					Δ = 5620 km. No definite maximum on vertical record. East-West seismograph out of order.
			e P_V	3 09 54					
			e_N	3 10 19					
			e S_N	3 17 35					
			e S_V	3 17 49					
			e L_V	3 26 34					
			M_N	3 31 17	18		10		
			F	4 34±					

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	
27	5 July	I_V	e	4 40 57					Dying energy of a near shock. No definite maximum on vertical; the record on that component consists of a long series of irregular waves of small amplitude and short period. Origin near Ferndale, California.
			M_E	4 42 28	3½	4			
			M_N	4 41 42	3½		6		
			F	4 47 49					
28	14 July	I?	e	23 59 20±					Barely perceptible trace of the chief phase of a distant earthquake.
			F	0 15±					
29	23 July	II_d	i P_E	9 09 55.3					Registered on the vertical component by a few minute vibrations. Marvin strong motion seismograph was started. The chattering of pen traces on sensitive seismographs made measurements somewhat difficult.
			i P_N	9 09 55.8					
			i L_E	9 09 56.5					
			i LM_N	9 09 57.2	½		186		
			M_E	9 09 57.6	<½	15			
			C	9 09 59					
			F	9 10 30±					
30	3 Aug.	I_d	e P_E?	1 47 01					eP obscured by microseisms. Measurement uncertain. Chief phase consists of barely perceptible long, flat waves.
			e S_{EN}	1 53 50					
			e L_E	2 01 02					
			F	3 55±					
31	3 Aug.	I_V	e P	13 49 48					*Monthly Weather Review* reports a shock at Elko, McDermitt, Rebel Creek and Winnemucca at 13h 50m.
			e L_N	13 50 43					
			e L_E	13 50 45					
			e L_V	13 50 48					
			M_E	13 51 05	4	10			
			M_{N_1}	13 51 14	4		8		
			M_V	13 52 05	5			6	
			M_{N_2}	13 53 06	5		14		
			C	13 53 13					
			F	13 58 08					
32	3 Aug.	II_V	e P_V	14 21 51					*Monthly Weather Review* reports a shock at Elko, McDermitt, Rebel Creek and Winnemucca at 14h 22m.
			e P_E	14 21 56					
			e_N	14 22 00					
			e L_{NV}	14 22 54					
			e L_E	14 22 56					
			M_{N_1}	14 23 48	7		46		
			M_V	14 24 14	6			34	
			M_E	14 24 28	6	65			
			M_{N_2}	14 25 14	8		76		
			C	14 26 23					
			F	14 35±					

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	
33	4 Aug.	I_V	e	4 12 29					Trace of a near earthquake. A series of weak vibrations on both horizontal components. No definite maximum.
			F	4 17 19					
34	6 Aug.	II_V	e_V	19 39 05					Chief phase consists of a combination of large waves of period 3–7 seconds on which are superposed minute vibrations of period ½–1 seconds with small amplitudes. Registered by both components of Omori tromometer. Marvin strong motion seismograph was started and an excellent record of the chief phase was obtained. *Monthly Weather Review* reports shocks felt at Hollister, Loanoak, Los Gatos, Merced, Paso Robles, San Francisco, Santa Cruz, Soledad, Spreckels. Shocks were also felt at Sausalito, San Mateo, Redwood City and Palo Alto.
			e_N	19 39 06					
			e_E	19 39 09					
			e L_V	19 39 36					
			e L_N	19 39 37					
			e L_E	19 39 39					
			M_N	19 40 00	4½		61		
			M_V	19 40 01	3			29	
			M_E	19 40 17	7½	86			
			C	19 42 53					
			F	19 51±					
35	6 Aug.	I_d	e P_V	20 56 47					Records consist of weak irregular waves of small amplitude and short period. Weak records on both components of Omori. *Monthly Weather Review* reports this earthquake felt at Hollister, Salinas and Spreckels at 20h 55m.
			e P_E	20 56 48					
			e P_N	20 56 49					
			e L_{NV}	20 57 05					
			M_{NV}	20 57 07	1–2	4	5		
			M_E	20 57 09	1			3	
			F	20 58 23					

No.	Date	Charac.	Phase	Time G. M. C. T.	Period	Amplitude			Remarks
				h m s	s	A_E μ	A_N μ	A_V μ	
	1916								
36	8 Aug.	II_V	i P_V	16 49 57					*Monthly Weather Review* reports this earthquake felt at Los Gatos, Santa Cruz, Soledad, and Spreckels at $16^h\ 50^m$. Shock was also felt at Stanford University. Registered by both components of Omori tromometer. Records of the chief phase obtained by Marvin strong motion seismograph.
			e P_E	16 49 57.6					
			e P_N	16 49 57.6					
			e L_N	16 50 12.2					
			e L_V	16 50 12.5					
			e L_E	16 50 13.3					
			M_E	16 50 14.6	3	46			
			M_N	16 50 17	$2\frac{3}{4}$		54		
			M_{V_1}	16 50 18	$2\frac{1}{2}$			29	
			M_{V_2}	16 50 42	$4\frac{1}{2}$			33	
			C	16 51 34					
			F	16 56 06					
37	9 Aug.	I_d	e	5 12 13					Records consist of a series of minute irregular waves. Horizontal components only.
			F	5 12 57					
38	23 Aug.	I_V	e	14 56 15					Series of barely perceptible vibrations on horizontal components. No trace of disturbance on vertical record. Felt strongly at Eureka, Arcata, and at other points in Northern Humboldt County.
			F	15 00 10					
39	28 Aug.	I_{V-u}	e P	6 58 30					No phases discernible. No trace of disturbance on East-West record. Barely perceptible on vertical record. From $6^h\ 58^m\ 30^s$ to $7^h\ 11^m\ 40^s$ there is weak motion of short period but no point can be recognized as S. After $7^h\ 11^m\ 40^s$ the movement dies away entirely. At $7^h\ 30^m$ a series of long flat sinusoidal waves begins and continues until $7^h\ 55^m$. Period 30 seconds, amplitude 2 microns.
			F	8 15±					
40	29 Aug.	I?	e	2 31 49					Barely perceptible long flat waves on East-West component only.
			F	3 20 30±					
41	3 Sept.	I?	e	7 55 17					Long flat waves representing trace of the chief phase of a distant earthquake. Very feeble on North-South component.
			F	8 35 40±					
42	5 Sept.	I?	e	22 54 51					Long flat waves. Trace of a distant earthquake. Visible on East-West and vertical components.
			F	23 34 40					
43	15 Sept.	I_u	*O*	*7 00 56*					Δ = 8520 km. Chief phase on vertical shows very small amplitude giving barely perceptible long flat waves.
			e P_V	7 12 48					
			e P_N	7 12 52					
			e P_E	7 12 55					
			e S_E?	7 22 19					
			e S_V	7 22 40					
			e S_N	7 22 43					
			e L	indefinite					
			M_E	7 35 07	11	2			
			M_N	7 38 45	18		2		
			C	indefinite					
			F	8 06±					
44	21 Sept.	I?	e	18 53 27					Trace of a distant earthquake. Barely perceptible on horizontal components.
			M_E	18 54 48					
			F	19 06 22					
45	23 Sept.	I_u	*O?*	*5 39 21*					Δ = 8080 km. No trace of disturbance on vertical.
			e P_{EN}?	5 50 46					
			e S_N?	6 00 25					
			M_N	6 00 25	18		6		
			M_E	6 11 53	21	5			
			F	6 45±					
46	24 Sept.	I?	e	19 48 41					Barely perceptible trace of a distant earthquake on East-West component only.
			F	20 10±					
47	26 Sept.	I_u?	e	22 12 34					Barely perceptible long flat waves on East-West component only.
			F	22 18 44					

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	28 Sept.	I_d	e	3 46 19					Series of very weak, barely perceptible vibrations on both horizontal components. Origin near Hollister.
			F	3 47 26					
49	30 Sept.	I_v	e	2 12 22					A series of weak vibrations on both horizontal components. Origin in Southern California. The *Monthly Weather Review* reports it felt at Coachella, Mecca, Riverside, San Diego and many other points in the southern part of the state.
			F	2 17 00					

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	6 Apr.	I_V	e	19 03 14					On North-South only. A series of waves whose amplitudes range from 1 to 2 microns and whose periods are between 7 and 8 seconds.
			F	19 11 09					
2	13 Apr.	I_d	e P	18 31 44.8					Registered on vertical component by a thickening of the pen trace and a displacement of the line.
			e L	18 31 48.8					
			M_{EN}	18 31 49.3	$<\frac{1}{2}$	6	4		
			C	18 31 55					
			F	18 32 00					
3	16 Apr.	I_r?	e	22 43 09					Trace of a near shock. Horizontal components only.
			F	22 55 00					
4	17 Apr.	I_d	e P	23 37 50					
			i L	23 37 53					
			M	23 37 54	$<\frac{1}{2}$	11	5	4	
			C	indefinite					
			F	23 38 01					
5	18 Apr.	I_r	*O*	*4 01 39*					Δ = 3880 km. The maximum movement comes near start of the second preliminaries and not during the chief phase. Recorded on East-West component but the record is illegible by reason of overscoring. Not registered by vertical instrument.
			e P_N	4 08 48					
			e S_N	4 14 28					
			M_{N_1}?	4 14 47	6		41		
			e L_N	4 17 30					
			M_{N_2}	4 17 46	9		12		
			C	indefinite					
			F	4 47±					
6	18 Apr.	I_d	e	23 25 41					Thickening of pen traces on all components.
			F	23 25 52					
7	18 Apr.	I_d	e	23 33 19					Thickening of pen traces on horizontal components.
			F	23 33 32					
8	18 Apr.	I_d	e	23 49 22					Record consists of a series of small vibrations of such short period that successive pen strokes overlap, producing a very strong thickening of the pen traces. Amplitude is greatest on the North-South component, where it is 5μ at the maximum.
			F	23 49 31					
9	18 Apr.	I_d	e	23 54 33					Thickening of pen traces on horizontal components.
			F	23 54 42					
10	21 Apr.	I_u	*O*	*11 32 09*					Δ = 8280 km. No definite maximum. Simple sinusoidal waves from 11^h 07^m to 11^h 15^m with periods and amplitudes of the values given opposite M_N and M_E. Not registered by the vertical seismograph.
			e P	11 43 44					
			e S	11 53 18					
			M_N		12		3		
			M_E		19	4			
			F	13 15±					
11	24 Apr.	I_u	*O*	*4 26 26*					Δ = 5520 km. See discussion in text.
			e P_N	4 35 27					
			i S_N	4 42 37					
			e L_N?	4 48 32					
			M_N	4 55 20	16		3		
			C	indefinite					
			F	5 15±					
12	24 Apr.	I_u	*O*	*8 01 48*					Δ = 5000 km. Not registered by vertical.
			e P	8 10 16					
			e S	8 16 58					
			e L	indefinite					
			M_E	8 31 27	20	6			
			M_N	8 36 07	14		10		
			C	indefinite					
			F	9 40±					
13	26 Apr.	I_r	*O*	*2 21 18*					Δ = 4750 km.
			e P	2 29 39					
			e S	2 36 16					
			e L?	2 41 44					
			M_N	2 47 26	20		3		
			M_E	2 48 01	20	2			
			F	3 25 01					
14	26 Apr.	I?	e	6 50±					Trace of a distant earthquake. Horizontal components only.
			F	7 15±					
15	4 May	I_d	e	0 09 18					Marked thickening of pen traces on all components.
			F	0 09 39					
16	5 May	I_d	e	0 52 57					Strong thickening of pen traces on all components.
			F	0 52 07					

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	5 May	I_d	e	1 11 15					Marked thickening of pen traces on all components.
			F	1 11 27					
18	8 May	I_d	e	21 21 52					Strong thickening of pen traces on both horizontal components. Not registered by vertical seismograph.
			F	21 22 06					
19	8 May	I_d	e	23 55 52					Marked thickening of pen traces on all components.
			F	23 56 39					
20	10 May	I_d	e P_N	16 16 23.2					Periods are so short that successive strokes of the pen cannot be separated. No phases discernible on East-West or vertical records.
			e L_N	16 16 27.5					
			M_N	16 16 30	$<\frac{1}{2}$		5		
			C	indefinite					
			F	16 16 37					
21	10 May	I_u	*O*	*21 36 26*					Δ = 5200 km. Time of beginning of first and second preliminaries appears to be well marked, but rest of the record consists of faint and barely perceptible vibrations in which there is no definite maximum and in which no phases are discernible.
			e P	21 45 07					
			e S	21 52 00					
			F	22 30±					
22	11 May	I_d	e P	7 50 29.2					Registered on the vertical component by a thickening of line and a shifting of the pen trace.
			i L	7 50 33.7					
			M_{EN}	7 50 40	2–3	11		25	
			C	7 50 58					
			F	7 52 56					
23	11 May	I?	e	10 08 31					Trace of a distant earthquake. No definite maximum on North-South component. Not registered by vertical seismograph.
			M_E	10 17 06	10		7		
			F	10 45±					
24	13 May	I_v	e	2 31 46					Barely perceptible vibrations in which no phases are discernible. Horizontal components only. Origin in Idaho.
			F	2 37 47					
25	16 May	I_d	e	0 22 05					Thickening of pen traces on all components.
			F	0 22 13					

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	
26	16 May	I_d	e	0 23 27					Thickening of pen traces on all components.
			F	0 23 34					
27	17 May	I_d	e	0 27 54					Thickening of pen traces on both horizontal components. Slight disturbance of pen on vertical.
			F	0 28 02					
28	17 May	I_d	e	0 37 20					Strong thickening of pen traces on horizontal components.
			F	0 37 32					
29	17 May	I_d	e	0 40 17					Thickening of pen traces on horizontal components.
			F	0 40 24					
30	17 May	I_d	e	0 55 41					Marked thickening of pen traces on all components.
			F	0 55 53					
31	25 May	I_d	e	0 02 26					Marked thickening of pen traces on all components.
			F	0 02 40					
32	1 June	I_d	e	23 59 41					Strong thickening of pen traces on horizontal components only.
			F	23 59 46					
33	2 June	I_d	e P	0 44 28					Registered on vertical component by a thickening of the line.
			e LM	0 44 31	$<\frac{1}{2}$	5		8	
			C	0 44 35					
			F	0 44 40					
34	7 June	I_d	e	0 04 13					Thickening of pen traces on horizontal components.
			F	0 04 22					
35	19 June	I_d	e	21 56 33					Thickening of the lines on North-South and on vertical component. Not registered on East-West component.
			F	21 56 43					
36	23 June	I_d	e	21 43 21					Thickening of pen traces on all components.
			F	21 43 33					
37	24 June	I_d	e	15 54 47					Strong thickening of pen traces on all components.
			F	15 54 59					
38	26 June	I_d	e	18 07 09					Thickening of pen traces on all components.
			F	18 07 21					

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	27 June	I_d	i P_V	13 43 17.0					*Monthly Weather Review* reports this earthquake felt at King City (III), Lonoak (IV), Salinas and Santa Cruz (III).
			i P_{EN}	13 43 17.9					
			e L_V	13 43 29.8					
			e L_{EN}	13 43 30.3					
			M_{EN}	13 43 39	2	44	45		
			M_V	13 43 48	3			11	
			C	13 44 00					
			F	13 45 30					
40	27 June	III_d	i P_N	14 15 28.9					See discussion in text.
			i P_E	14 15 29.4					
			i P_V	14 15 29.8					
			i LM_N	14 15 30.8	½		>380		
			i LM_V	14 15 31.1	½			57	
			i LM_E	14 15 31.2	½	492			
			C	14 15 44					
			F	14 17 25					
41	27 June	I_d	e	19 27 42					Marked thickening of pen traces on all components.
			F	19 27 52					
42	27 June	I_d	e	23 52 08					Thickening of lines on records of all components.
			F	23 52 19					
43	29 June	I_d	e	22 24 07					Strong thickening of pen traces on all components.
			F	22 24 19					
44	30 June	I_u	*O*	*3 00 23*					Δ = 5820 km. Barely perceptible waves on East-West component. Not registered by vertical seismograph.
			e P_N	3 09 43					
			e S_N	3 17 09					
			e L_N?	3 24 08					
			M_N	3 31 35					
			C	indefinite					
			F	4 54+					
45	30 June	I_d	e	21 50 39					Thickening of pen traces on all components.
			F	21 51 50					
46	30 June	I_d	e	21 56 29					Thickening of pen traces on horizontal components.
			F	21 56 44					
47	5 July	I_v	e	4 40 56					Weak record of an earthquake originating near Ferndale. Very faint on East-West and not perceptible on vertical component.
			M	4 42 47	2			4	
			F	4 47 46					
48	7 July	I_d	e	16 13 03					Thickening of pen traces on all components.
			F	16 13 14					

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	
49	7 July	I_d	e	23 28 04					Strong thickening of pen traces on all components.
			F	23 28 15					
50	9 July	II_d	i P_{EN}	18 54 05.8					
			i P_V	18 54 06.0					
			i LM_{EN}	18 54 07.0	½	65	40		
			i LM_V	18 54 07.1	½			7	
			C	18 54 11					
			F	18 55 17					
51	12 July	I_d	e	2 25 25					Trace of weak near shock. A few weak waves on horizontal components.
			F	2 26 07					

During the days from the 15th to the 18th of July, no clock corrections were obtained at the Lick Observatory Station. The absolute times of occurrence of the phases of the next following earthquakes may be in error by a few seconds.

52	15 July	I_d	e	0 26 57					Thickening of pen traces on all components. Clock correction uncertain.
			F	0 27 09					
53	15 July	I_d	e	0 29 26					Thickening of pen traces on all components. Clock correction uncertain.
			F	0 29 37					
54	17 July	I_d	e	16 55 50					Strong thickening of pen traces on all components. Clock correction uncertain.
			F	16 55 02					
55	17 July	I_d	e	19 09 39					Thickening of pen traces on North-South and vertical components. Clock correction uncertain.
			F	19 09 44					
56	17 July	I_d	e	21 01 24					Thickening of pen traces on North-South and vertical components. Clock correction uncertain.
			F	21 01 30					

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	18 July	I_d	i P	16 29 46.4					Thickening of pen traces on East-West and vertical components. On North-South record definite phases are discernible but periods are so short that successive pen strokes have entirely removed the smoke from the paper. The record then consists of a strong thickening of the line and the phases are recognized by reason of changes in amplitude. Clock correction uncertain.
			i L	16 29 48.3					
			M_N	16 29 49	$<\frac{1}{2}$		5		
			C	16 29 54					
			F	16 30 00					
58	18 July	I_d	e	19 57 26					Strong thickening of pen traces on North-South and vertical components. Slight disturbance on East-West component. A definite maximum appears only on North-South component.
			M_N	19 57 34	$<\frac{1}{2}$		5		
			F	19 57 40					
59	19 July	I_d	e	22 57 47					Recorded on East-West by a thickening of pen traces with no definite maximum. On North-South and on vertical components the records consist of a thickening of the pen traces which is small at first, gradually increases to a maximum, and then dies away
			M_{NV}	22 57 55	$<\frac{1}{2}$	5		4	
			F	22 58 02					
60	25 July	I_d	e	19 54 33					Strong thickening of pen traces on all components.
			F	19 54 43					
61	27 July	I_d	e	16 35 07					Strong thickening of pen traces on all components. No definite maximum on East-West record.
			M_{NV}	16 35 13	$<\frac{1}{2}$	4		4	
			F	16 35 20					
62	27 July	I_d	e	16 41 27					Strong thickening of pen traces on all components.
			F	16 41 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	
63	27 July	I_d	e	0 16 19					Thickening of pen traces on all components. No definite maximum on East-West.
			M_{NV}	0 16 25	$<\frac{1}{2}$	5		4	
			F	0 16 32					
64	1 Aug.	I_d	e	0 31 34					Thickening of pen traces on all components.
			F	0 31 45					
65	1 Aug.	I_d*	e	16 19 15					Strong thickening of pen traces on all components.
			F	16 19 28					
66	1 Aug.	I_d	e	16 38 17					Strong thickening of pen traces on all components. No maximum on East-West record.
			M_{NV}	16 38 23	$<\frac{1}{2}$	4		4	
			F	16 38 30					
67	1 Aug.	I_d	e	17 10 31					Strong thickening of pen traces on all components. No definite maximum on East-West component.
			M_V	17 10 34	$<\frac{1}{2}$			5	
			M_N	17 10 35	$<\frac{1}{2}$	4			
			F	17 10 40					
68	1 Aug.	I_d	e	21 05 43					Strong thickening of pen traces on all components.
			F	21 05 55					
69	1 Aug.	I_d	e	21 28 35					Strong thickening of pen traces on all three components. Maxima on East-West and vertical components are sharply defined. On the North-South record the amplitudes gradually increase up to a maximum and then die away gradually.
			M_E	21 28 39	$<\frac{1}{2}$	2			
			M_V	21 28 40	$<\frac{1}{2}$			5	
			M_N	21 28 42	$<\frac{1}{2}$		4		
			F	21 28 48					
70	2 Aug.	I_d	e	19 22 06					Marked thickening of pen traces on North-South and vertical components.
			F	19 22 19					
71	3 Aug.	I_d	e	1 08 11					Strong thickening of pen traces on all components. Times given are somewhat uncertain on account of the failure of minute marks.
			F	1 08 22					

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	
72	3 Aug.	I_r?	e P	1 47 23					North-South component only. Trace of a distant earthquake. Beginning sharply marked but main phase and second preliminaries are barely perceptible.
			F	2 40±					
73	3 Aug.	I_V	e P	13 49 46					Not registered by vertical seismograph. Barely perceptible on East-West component. Times given are somewhat uncertain because of failure of time markers to indicate the minutes. *Monthly Weather Review* reports this earthquake felt at Elko, McDermitt, Rebel Creek and Winnemucca, Nevada, at $13^h\ 50^m$.
			e L	13 50 52					
			M_N	13 50 59	3		15		
			C	indefinite					
			F	13 59±					
74	3 Aug.	I_V	e P	14 21 36					Not registered by vertical seismograph. Poor record on East-West component. *Monthly Weather Review* reports an earthquake at McDermitt, Rebel Creek, and Winnemucca, Nevada, at $14^h\ 22^m$.
			e L	14 22 52					
			M_1	14 23 04	6	52			
			M_2	14 23 59	5		56		
			C	14 26 32					
			F	14 37±					
75	4 Aug.	I_d	e	19 01 50					Marked thickening of pen traces on records of all components.
			F	19 02 04					
76	4 Aug.	I_V	e	4 12 33					Series of weak vibrations on North-South component representing the dying energy of a near shock. Faint disturbance on East-West record but nothing perceptible on vertical record.
			M	4 13 00	1½		4		
			F	4 15 07					
77	4 Aug.	I_d	e	18 32 36					Strong thickening of pen traces on all components.
			F	18 32 49					
78	5 Aug.	I_d	e	0 19 16					Strong thickening of pen traces on all components.
			F	0 19 31					

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	
79	6 Aug.	III_V	e P_N	19 38 38					Pen off paper at time of M_E. *Monthly Weather Review* reports this earthquake felt at Hollister, Lonoak, Los Gatos, Merced, Paso Robles, San Francisco, Santa Cruz, Soledad and Spreckels at $19^h\ 40^m$.
			e P_{EV}	19 38 39					
			i L_{EN}	19 39 28					
			i L_V	19 39 29					
			M_V	19 39 42	4			50	
			M_E	19 39 48	5	>348			
			M_N	19 39 57	6		329		
			C	19 42 08					
			F	19 58±					
80	6 Aug.	II_d	i P_N	20 56 41.4					*Monthly Weather Review* reports this earthquake felt at Hollister, Salinas and Spreckels at $20^h\ 55^m$.
			e P_E	20 56 42.6					
			i LM_E	20 56 49.5	2½	381			
			i L_N	20 56 49.5					
			M_{NV}	20 56 51	½		188	5	
			C	20 56 57					
			F	20 58 43					
81	7 Aug.	I_d	e P	16 40 34					Registered on East-West component by a thickening of the pen trace.
			e L	16 40 39					
			M_{NV}	16 40 41	<½		5	4	
			F	16 40 49					
82	7 Aug.	I_d	e	18 00 43					Strong thickening of pen traces on all components.
			F	18 00 54					
83	7 Aug.	I_d	e P	22 23 18					Barely perceptible disturbance on East-West component. Thickening of pen trace on vertical record.
			i LM	22 23 25	<½		4		
			C	indefinite					
			F	22 23 34					
84	8 Aug.	I_d	e	16 39 40					Strong thickening of pen traces on all components.
			F	16 39 56					
85	8 Aug.	III_d	i P_V	16 49 44.5					First shift of ground at Lick Observatory was West, South, and down. Origin lies to the southwest of the station on San Andreas fault. *Monthly Weather Review* reports this shock felt at Los Gatos, Santa Cruz, Soledad and Spreckels at $16^h\ 50^m$.
			e P_N	16 49 47.6					
			e P_E	16 49 48.2					
			i L_V	16 49 49.7					
			i L_N	16 49 50.5					
			i L_E	16 49 52.9					
			M_E	16 50 00	6	394			
			M_N	16 50 01	5½		375		
			M_V	16 50 01	3½			175	
			C	16 50 29					
			F	16 57 19					
86	9 Aug.	I_d	e	5 11 58					Trace of a local shock on horizontal components only. Periods are so short that records are only a thickening of the pen traces.
			M	5 12 06	½	4	4		
			F	5 12 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	
87	9 Aug.	I_d	e	22 18 57					A series of weak irregular vibrations on all components.
			F	22 19 12					
88	14 Aug.	I_d	e	12 34 57					Thickening of pen traces on all components.
			F	12 35 06					
89	15 Aug.	I_d	e	0 46 54					Thickening of pen traces on all components.
			F	0 46 10					
90	15 Aug.	I_d	i	0 49 24					Strong thickening of pen traces on North-South component. Weak on the vertical and East-West components.
			M	0 49 27	$<\frac{1}{2}$		6		
			F	0 49 34					
91	15 Aug.	I_d	e	1 01 35					Thickening of pen traces on all components.
			F	1 01 48					
92	16 Aug.	I_d	e	1 05 14					Thickening of pen traces on all components.
			F	1 05 23					
93	16 Aug.	I_d	e	1 14 18					A series of short period vibrations on North-South component.
			F	1 14 27					
94	22 Aug.	I_d	e	16 18 24					Not registered by East-West component as this part of the instrument was out of order. Periods so short that successive pen strokes overlap and smoke is completely removed except between outer ends of successive maxima.
			M_{NV}	16 18 34	$<\frac{1}{2}$	11	5		
			F	16 18 40					
95	23 Aug.	I_d	e	16 07 54					Strong thickening of pen traces on all components.
			F	16 08 12					
96	28 Aug.	I_d	e	23 55 47					Strong thickening of pen traces on all components.
			F	23 55 58					
97	29 Aug.	I_d	e	0 27 28					Thickening of pen traces on all components.
			F	0 27 41					
98	29 Aug.	I_d	e P	21 22 32					Registered on East-West component by a thickening of the pen trace.
			i LM	21 22 38	$<\frac{1}{2}$		11	4	
			C	21 22 47					
			F	21 22 58					

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	
99	31 Aug.	I_d	e	21 15 30					Strongly marked thickening of pen traces on East-West and vertical components.
			M_N	21 15 40	$<\frac{1}{2}$		11		
			F	21 15 46					
100	1 Sept.	I_d	i P	0 09 11.5					Registered on East-West component by a thickening of pen traces.
			i L	0 09 15					
			M	0 09 16	$<\frac{1}{2}$		11	4	
			C	0 09 21					
			F	0 09 27					
101	1 Sept.	I_d	e	2 05 10					A series of very weak irregular waves on all components.
			F	2 05 40					
102	9 Sept.	I_d	i P	15 54 05					Registered on vertical component by a thickening of the pen trace.
			e L	15 54 10					
			M	15 54 12	$<\frac{1}{2}$	4	12		
			C	15 54 18					
			F	15 54 30					
103	9 Sept.	I_d	e	21 41 01					Registered only on the North-South component.
			M	21 41 05	$<\frac{1}{2}$		3		
			F	21 41 07					
104	15 Sept.	I_r?	e P?	7 12 51					Barely perceptible record on North-South component. Phases not separable.
			F	8 04±					
105	18 Sept.	I_d	e P_N	22 44 16.6					Registered on East-West component by a thickening of the pen trace. Not recorded by vertical seismograph.
			i L_N	20 44 20.0					
			M_N	20 44 21	$<\frac{1}{2}$		19		
			C	20 44 27					
			F	20 44 32					
106	19 Sept.	I_d	e	23 45 34					Thickening of pen traces on horizontal components. Weak on East-West component.
			M_N	23 45 40	$<\frac{1}{2}$		5		
			F	23 45 50					
107	19 Sept.	I_d	e P_N	23 51 40					Horizontal components only. Registered on East-West component by a thickening of pen traces.
			M_N	23 51 44	$<\frac{1}{2}$		6		
			F	23 51 55					
108	20 Sept.	I_d	e	0 13 49					Registered on vertical component by a slight thickening of pen traces.
			M_N	0 13 56	$<\frac{1}{2}$	3	9		
			C	0 14 01					
			F	0 14 05					
109	20 Sept.	I_d	e P_{NV}	19 25 54					Preliminary tremor not registered on East-West component.
			i LM	19 25 59	$<\frac{1}{2}$	2	8	3	
			C	19 26 02					
			F	19 26 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	
110	23 Sept.	I_a?	e P?	5 51 01					North-South component only.
			M	6 14 18	15		2		
			F	6 34±					
111	28 Sept.	I_d	e	15 46 02					Origin near Hollister. Series of weak irregular vibrations on horizontal components.
			M_N	15 46 16	$<\frac{1}{2}$		4		
			M_E	15 46 22	$<\frac{1}{2}$	5			
			F	15 47 33					
112	30 Sept.	I_v	e	2 12 19					A series of very weak vibrations on North-South component only. *Monthly Weather Review* reports an earthquake felt in Southern California, at Coachella, Mecca, Riverside, and San Diego at $2^h\,11^m$.
			F	2 14 26					

DISCUSSION OF PARTICULAR EARTHQUAKES

During a part of the period covered by this bulletin, construction was in progress on the south wing of the University Library in which the instruments of the Berkeley station are installed. While the disturbance to the instruments was slight and insufficient to affect the registration of ordinary earthquakes, it is possible that some feeble shocks may have been obscured.

Teleseism of April 7, 1916

At Berkeley this earthquake began gradually with waves of small amplitude and short period which continued until the time of beginning of the second preliminary tremors. There was then a sudden increase in amplitude. After three or four minutes the amplitude of the second preliminaries died away and only very slight movements of the ground occurred thereafter. The chief phase began so gradually that its time of beginning could not be determined. There was no well-defined maximum and, with the exception of a group of sinusoidal waves continuing from $10^h\,01^m$ to $10^h\,13^m$, the chief phase was a series of irregular waves of varying period and small amplitude. The period of the sinusoidal waves ranged from 17 to 18 seconds and the amplitudes averaged three microns.

This earthquake was not recorded at the Lick Observatory.

Teleseism of April 24, 1916

At the Berkeley Station, this earthquake (No. 11) gave records on both horizontal components and was registered on the vertical seismograph by a few sinusoidal waves. The first movement of the ground began very gradually and the first preliminaries were barely perceptible, irregular waves of short period and small amplitude. The second preliminaries began abruptly with a sudden shift of the pen. Their character was very similar to those vibrations which made up the first preliminary tremors, save that their amplitudes were larger. The transition between the second preliminaries and the main phase

was so gradual that it was not possible to determine the time of beginning of the chief phase. No definite maximum appeared on the seismograms, and after the beginning of the second preliminary tremors the movement gradually died away. The two horizontal components were very much alike in all their characters, but the amplitudes on the East-West component were in all instances a little larger than those on the North-South component.

At the Lick Observatory this earthquake (No. 11) was well registered on the North-South component; on the East-West component it was represented by a few vibrations; while on the vertical component no movement was apparent. The records were rather peculiar in their character. They began rather gradually with vibrations of short period—one second or less—and amplitudes ranging from one to two microns. These vibrations lasted about a minute. The period then increased up to three or four seconds while the amplitude still remained small so that this portion of the seismogram consisted of barely perceptible long flat vibrations. This type of movement was brought to a close by the first impulse of the second preliminaries, which showed an amplitude of about eight microns with a period of three to four seconds. After this, well marked vibrations with amplitudes of three to four microns and periods of three to four seconds continued for about two minutes. Then the amplitudes decreased to one micron or less though the periods remained about the same. The beginning of the main phase was determined by noting the point where the periods began to increase. During the first part of the chief phase the amplitudes were small, usually less than one micron. The periods range from eight to fifteen seconds. At the time of the maximum a few waves of larger amplitude were registered, after which the movement gradually died away.

Strong Local Shock of June 27, 1916

At the Lick Observatory this earthquake was too strong for satisfactory registration. The East-West component record was decidedly asymetric, the movements of the pen being much greater in a direction East of the mean position than to the West

of it. The North-South component record is symmetrical as far as can be judged. The intensity was a little too great for satisfactory registration and as a result the records show tangled lines which interfere somewhat with satisfactory measurement of the phases. The chattering of the pen on the North-South component was so great that only a portion of the main phase could be made out. The value given for the amplitude of the maximum on that component is possibly not equal to the full value of the displacement.

An excellent record was written by the vertical seismograph. The first shift of the ground was upward, indicating that the disturbance began with a wave of expansion. Since the first shift of the ground, as indicated by the horizontal components was Northeast, the origin must have been to the Southwest of the Lick Station. The distance of origin was between eight and ten miles. The earthquake was, therefore, due to a slip on the Haywards fault.

At Berkeley the seismograms were very weak, but the phases were readily determinable.

The Monthly Weather Review reports this earthquake felt at Paso Robles, San José, and Santa Cruz.