

THE WALNUT, CALIFORNIA, EARTHQUAKES OF JULY-AUGUST, 1959

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ABSTRACT

A swarm of minor earthquakes began on July 29, 1959, near $34^{\circ} 00' N$, $117^{\circ} 48' W$. Records at Pasadena show P and S waves reflected from the Moho. A portable instrument recorded some of these at a point about 6 km. from the epicenter. The characteristic false S - P of about one second at short distances was recorded.

ON JULY 29, 1959, a swarm of small earthquakes was recorded at the Pasadena station; these continued and were observed under circumstances of unusual interest.

The larger of the group were noticed at Pomona; many more were felt at La Puente (Puente on old maps), the nearest considerable town to the probable epicenter. Table 1 lists those of magnitude 2.2 and over, through September 1. This magnitude corresponds to recorded maximum trace amplitudes at Pasadena of 0.3 mm. on the north-south and east-west torsion seismometers and about 3 mm. on the records of the Benioff short-period vertical-component seismometers.

An ink-writing portable instrument was operated overnight, July 29-30, at a point near the crest of the Puente Hills, about $35^{\circ} 59'6'' N$, $117^{\circ} 59'9'' W$. A few small earthquakes of the group were recorded, with indication of short epicentral distance; the times of the first recorded motion probably do not represent the P wave.

Through the courtesy of Mrs. J. O. Hamilton a photographically recording seismometer was operated August 4-16 at a locality here called La Brea, on the crest of hills west of Brea Canyon, just above the summit of the Brea Canyon Cutoff Road. The position was $33^{\circ} 58'6'' N$, $117^{\circ} 51'6'' W$, elevation 1,000 feet.

Seismograms written at La Brea show the appearance typical of very short distances, with an apparent S - P interval near one second, the second arrival probably not being the true S.

Seismograms at Pasadena show a definite resemblance to those of the Whittier earthquake group of 1929.¹ Between P and S, and following S, there are clearly recorded waves which appear to represent reflection from the Mohorovičić discontinuity. Such waves are not clearly recorded at Riverside although the distance is nearly the same as for Pasadena.

Determinations of the epicenter and origin time depend critically on recorded times at Pasadena, Riverside, and Mount Wilson. (The station at Dalton unfortunately was put out of action just before these earthquakes began.) Timing at Mount Wilson proved especially difficult owing to the uneven rotation of the drum in a period of about a minute; this was examined and compensated for in detail, the correction to the time determinations not exceeding 0.8 second.

Table 2 presents data for the larger of these shocks and for a few of the larger ones recorded at La Brea. Tabulated times are subsequent to the assumed times of

Manuscript received for publication October 7, 1959.

¹ H. O. Wood and C. F. Richter, "Recent Earthquakes near Whittier, California," *Bull. Seism. Soc. Am.*, 21: 183-203 (1931); C. F. Richter, *Elementary Seismology* (San Francisco: W. H. Freeman & Co., 1958), chap. iv.

origin tabulated for the individual shocks. It will be seen that the general agreement among the shocks is good, and it is reasonable to assume that they originated at nearly a common point.

Table 3 is based on interpretation of the readings of a single representative shock,

TABLE 1
SHOCKS OF MAGNITUDE 2.2 AND MORE, JULY-AUGUST, 1959, WITH
EPICENTER NEAR 34° 00' N, 117° 48' W

Date	Time	Magnitude
	h. m.	
July 29.....	16 30	2.2
	16 48	2.9
	17 33	2.8
	18 39	2.8
	19 13	2.3
	19 14	2.3
	20 14	3.1
	21 26	2.8
	21 29	3.3
	22 03	2.7
July 30.....	00 02	2.2
	00 03	2.2
	09 04	2.3
	12 04	2.2
	12 06	2.2
Aug. 1.....	14 23	2.3
	14 25	2.3
Aug. 3.....	15 26	3.5
	17 06	2.2
	17 15	2.2
	17 54	2.9
	18 26	2.2
	18 36	2.5
Aug. 5.....	03 30	2.3
Aug. 6.....	03 02	2.3

assuming epicenter 34° 00' N, 117° 48' W, and hypocentral depth of 10 km. The best origin time appears to be 3 August 1959, 15:26:42.5.

Assumptions used, as in previous publications, are: velocity of P at short distances, 6.34 km/sec.; effective horizontal velocity of P_n, 8.2 km/sec.; velocity ratio P/S, 1.73. Entries for La Brea in parentheses are not those of the given shock, but the mean results derived by comparison with the data of other shocks listed in tables 1 and 2.

Small variations in assumed depth affect only the fit at La Brea; if the assump-

tions are applied rigidly, the La Brea time of P determines the depth as about $3\frac{1}{2}$ km. Beneath the station is a thick Tertiary section, which might be expected to delay the arrival of P; the true hypocentral depth may therefore be even less. The apparent recorded S - P interval of 0.8 to 1.2 sec. (usually most clearly legible for

TABLE 2
P AND S TRAVEL TIMES FOR SOME OF THE LARGER SHOCKS

Date.....	July 29 16:48:35.2	July 29 20:14:46.1	July 29 21:29:09.3	August 3 15:26:42.5	August 3 17:54:14.6	August 5 03:30:59.0	August 6 03:02:22.5
Origin time.....	2.9	3.1	3.3	3.5	2.9	2.3	2.3
Magnitude.....							
Station*	P travel times						
LB.....	....	....	....	....	....	1.1	1.3
MW.....	6.1	....	6.1	6.0	6.3	6.0	6.0
P.....	5.9	6.2	6.1	6.1	5.7	5.9	6.0
R.....	6.5	6.4	6.3	6.4	6.4	6.4	6.4
PV.....	14.1	13.2	11.1	9.2	....	....	....
Pr.....	18.0	17.9	18.0	18.1	....	18.2	18.0
FT.....	23.1	22.7	22.1	23.0	....	21.8	....
Bt.....	27.4	27.1	27.2	27.5	27.6	27.6	27.9
SN.....	27.8	30.6	28.6	29.0	....	....	....
Is.....	30.3	30.0	29.5	30.1	30.4	33.2	33.3
CL.....	31.6	31.2	31.4	31.6	31.5	34.1	34.6
Hf.....	....	....	....	31.2	30.9	....	....
W.....	32.8	32.8	31.9	31.8	33.3	32.3	33.2
Kg.....	40.2	35.1	35.4	36.8	41.8	....	....
H.....	....	....	....	39.2	43.9	....	....
T.....	....	....	....	52.1	54.8	....	....
	S travel times						
MW.....	....	....	....	....	....	11.2	11.1
P.....	11.2	10.9	11.1	11.1	11.2	10.5	10.5
R.....	11.3	11.1	11.3	10.7	11.1	11.5	11.5
PV.....	29.3	27.4	26.5	26.4	....	....	....
Pr.....	31.3	30.8	31.3	30.9	....	31.5	31.5
FT.....	39.0	39.2	40.4	39.3	....	41.4	....
Bt.....	47.4	47.4	47.3	47.7	47.8	48.3	48.7

* Station abbreviations: Barrett, Bt; La Brea, LB; China Lake, CL; Fort Tejon, FT; Haiwee, H; Hayfield, Hf; Isabella, Is; King Ranch, Kg; Mount Wilson, MW; Palomar, Pr; Palos Verdes, PV; Pasadena, P; Riverside, R; San Nicolas, SN; Tinemaha, T; and Woody, W.

small shocks), with P and S velocities of 6.34 and 3.66 km/sec., would imply a depth of about 6 km. In other words, as found in many other instances of recording at short distance, the large wave following P and after about 1 second is not S.

Table 3A gives data and interpretation for a small shock on August 14 with slightly different epicenter; this is of special interest only because of its having been recorded at La Brea. Other and larger shocks have been recorded in the past in the same vicinity.

At Pasadena these earthquakes typically record with S - P of 5.0 sec., the P re-

TABLE 3
 DATA FOR EARTHQUAKE OF AUGUST 3, 1959, 15^h 26^m 42^s.5, GCT,
 REFERRED TO 34° 00' N, 117° 48' W

Station	P 15:26	Δ	P-O ($k=10$ km.)	O 15:26	$\Delta/8.2$	P- $\Delta/8.2$	S-P	1.37(S-P)	O 15:26
LB.....	(43.6)	6.1	1.8	(41.8)	.....	.....	.....	.....	.....
MW.....	48.5	34.4	5.6	42.9	.....	.....	.....	.....	.....
P.....	48.6	38.0	6.2	42.4	.....	.....	5.0	6.9	41.7
R.....	48.9	39.3	6.4	42.5	.....	.....	4.3	5.9	43.0
PV.....	51.7	58.1	9.3	42.4	.....	.....	.....	.....	.....
Pr.....	60.6	113.2	18.0	42.6	13.7	46.9	12.8	17.5	43.1
FT.....	65.5	139.7	22.1	43.4	17.1	48.4	16.3	22.3	43.2
Bt.....	70.0	181.6	28.8	41.2	22.1	47.9	20.2	27.7	42.3
SN.....	71.5	180.3	28.6	42.9	22.0	49.5	20.3	27.8	43.7
Is.....	72.6	192.6	30.5	42.1	23.5	49.1	22.5	30.8	41.8
CL.....	74.1	202.3	32.0	42.1	24.7	49.4	.....	.....	.....
Hf.....	73.7	202.8	32.1	41.6	24.8	48.9	.....	.....	.....
W.....	74.3	211.3	33.4	40.9	25.7	48.6	.....	.....	.....
Kg.....	79.3	231.3	36.6	42.7	28.2	51.1	.....	.....	.....
H.....	81.7	237.5	37.5	44.2	28.9	52.8	.....	.....	.....
T.....	94.6	341.2	.....	.....	41.6	53.0	.....	.....	.....

TABLE 3A
 DATA FOR EARTHQUAKE OF AUGUST 14, 1959, 03^h 15^m 16^s.9,
 REFERRED TO 33° 50' N, 117° 42' W

Station	P 03:15	Δ	P-O ($k=10$ km.)	O 03:15	$\Delta/8.2$	P- $\Delta/8.2$	S-P	1.37(S-P)	O 03:15
LB.....	20.7	21.7	3.8	16.9	.....	.....	.....	.....	.....
R.....	22.7	34.9	5.7	17.0	.....	.....	4.4	6.0	16.7
MW.....	25.7	54.5	8.7	17.0	.....	.....	5.6	7.7	18.0
P.....	25.8	55.9	9.0	16.8	.....	.....	5.6	7.7	18.1
Pr.....	32.1	94.8	15.0	17.1	.....	.....	14.6	20.0	12.1
FT.....	41.7	159.4	25.2	16.5	19.4	22.3	18.5	25.3	16.4
Bt.....	41.9	159.8	25.2	16.7	19.5	22.4	20.4	27.9	21.5
Hf.....	50.2	191.6	30.3	19.9	23.4	26.8	22.6	31.0	19.2
Is.....	49.1	215.0	34.0	15.1	26.2	22.9	.....	.....	.....
CL.....	52.4	220.1	34.8	17.6	26.8	25.6	.....	.....	.....
W.....	51.3	232.3	36.7	14.6	28.3	23.0	.....	.....	.....

flected from the Moho following P by 1.4 sec., while the corresponding S reflection follows the direct S by 2.8 sec.

This may be compared with the corresponding times for the Whittier earthquakes of 1929,² in which S - P at Pasadena was typically 4.0 sec., with the reflected S following direct S after 4.4 sec. The depth of the reflections is of the order of 28 to 30 km.

Directions of first motion were consistent at the individual stations for the main group of shocks, especially the larger and better-recorded ones. Dilatations were regularly recorded at Pasadena, Mount Wilson, Barrett; at Palomar, initial dilatation is often followed by a larger compression. Compressions were recorded very consistently at Riverside; the few reliable determinations of direction at Isabella, China Lake, and Woody show compressions.

The shock of August 14, 03:15, shows clear initial dilatation at Pasadena, Mount Wilson, Riverside, and Palomar.

The epicenter at 34° 00' N, 117° 48' W, is not close to the surface trace of any considerable fault. These shocks definitely cannot be referred to the Norwalk fault, as was done for those of 1929. The epicenter lies about 7 km. north-northeast of the Whittier thrust fault, which dips in that direction; but a dip of 30° would be required to put the hypocenter on the fault surface at a depth of 3½ km.

The sequence of shocks is unusual for the Los Angeles area, being rather of the swarm type than following the usual aftershock pattern. As this is written, in September, 1959, the possibility still remains that these are foreshocks of a more considerable event. (The group of shocks culminating in the Whittier earthquake of July 8, 1929, began on May 4.)

The only place appearing on small-scale maps in the vicinity of the given epicenter is Walnut Station on the Union Pacific Railroad.

ACKNOWLEDGMENTS

Work on these shocks was carried out largely on funds provided by the National Science Foundation project NSF-G6065. In the operation and maintenance of the temporary stations, the authors wish to acknowledge the generous coöperation of Mr. Shelton Alexander, Mr. David Harkrider, and Mr. Stewart Smith.

² Wood and Richter, *op. cit.*; Richter, *op. cit.*, pp. 43, 44.