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DIRECTION OF FAULTING IN SOME OF THE LARGER EARTHQUAKES OF 1955-1956

BY

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ABSTRACT

Fault-plane solutions are presented for fifteen of the larger earthquakes of 1955-1956, and the solutions are summarized in tabular form.

INTRODUCTION

The fault-plane project of this Observatory was recently examined in two papers (Hodgson, 1957; Hodgson and Adams, 1958) in which it was concluded that the techniques of the project had justified themselves sufficiently that the program should be continued, but that reflected phases should not be used. This is the second paper of a new series produced with this limitation in mind. The solutions have been based on P and PKP only, but in each case reflected phases reported in the questionnaires have been tested for consistency against the completed solutions. This has provided additional information on the reliability of these phases.

Because the earlier statistical study (Hodgson and Adams, 1958) suggested that all stations are not equally reliable and that good stations sometimes have their galvanometers accidently reversed, a new technique has been adopted in the present paper. Tentative solutions were made for as many of the earthquakes as possible. Each station was then tested for consistency with these solutions, and a chronological list was made showing the consistent and inconsistent observations for each station. Stations which were inconsistent about as often as they were consistent were given very low weight in subsequent revision of the solutions. If a particular station had been consistent most of the time up until a certain date, and then became inconsistent most of the time, a letter was sent to the station suggesting that their galvanometer might have become reversed and indicating the approximate date of this. There were nine such stations, on five different continents. Our suspicions were confirmed at seven of the stations and proved to be unfounded for one; the ninth station has not replied. The solutions were then all remade in the light of these findings; reversed observations were corrected and stations with random observations were given very low weight. The fact that our suspicions had been incorrect in one case led us to discard the solutions on which that suspicion had been based. This new method permits an earlier appraisal of station reliability and a more accurate determination of solutions.

Data used in this paper derive from questionnaires circulated in September, 1956, and in May, 1957. These covered 29 principal earthquakes and 7 aftershocks. Fifteen solutions have been obtained, a much smaller percentage than usual. This is largely due to the fact that all the aftershocks and four of the principal shocks were too small to provide sufficient data. Two other earthquakes failed to provide unique solutions; the suggestion will be made that these earthquakes resulted from some mechanism other than failure under a couple.

PRESENTATION OF THE DATA

Table I lists in three groups the 29 principal earthquakes for which solutions were attempted. The first group contains earthquakes for which no solutions could be obtained,

TABLE I

LIST OF THE EARTHQUAKES CONSIDERED

Date	H (G.M.T.)	Epicentre φ	Epicentre λ	Focal Depth	Magnitude	Remarks
Earthquakes for which solutions have not been obtained						
Sept. 26, 1955.....	08:28:20	15½°N	92½°W	0.03R	6¾	Conflict of data
Oct. 10, 1955.....	08:57:44	5°S	153°E	0.00R	7½	Conflict of data
Dec. 7, 1955.....	15:03:11	26½°N	142½°E	0.00R	6¾ to 7	Conflict of data
Jan. 16, 1956.....	23:37:37	½°S	80½°W	0.00R	7¼ to 7½	Conflict of data
Mar. 13, 1956.....	13:13:10	7°N	82°W	0.00R	7	Too few and conflicting data
Mar. 22, 1956.....	06:33:55	3½°S	79°W	0.01R	6¾ to 7	Conflict of data
Apr. 18, 1956.....	11:00:13	52°N	178°W	0.00R	6¾	Too few data
June 9A, 1956.....	10:08:32	30½°S	70½°W	0.02R	6¾	Too few and conflicting data
June 9B, 1956.....	23:13:51	35½°N	67½°E	0.00R	7¼ to 7½	Conflict of data
July 17, 1956.....	07:34:07	7°S	126½°E	0.07R	6¾	Conflict of data
July 18, 1956.....	06:19:15	5°S	130°E	0.00R	7¼ to 7½	Conflict of data
July 23, 1956.....	19:25:58	24°S	112°W	0.00R	6¾	Too few data
Earthquakes for which solutions have been obtained						
Aug. 16, 1955.....	11:46:58	6°S	155°E	0.03R	7½	
Aug. 21, 1955.....	17:33:58	3°S	137½°E	0.00R	6¾ to 7	
Aug. 28, 1955.....	20:13:30	14°N	91°W	0.01R	6¾	
Sept. 12, 1955.....	06:09:20	32½°N	30°E	0.00R	6¾	
Oct. 13, 1955.....	09:26:44	9½°S	161°E	0.00R	7	
Nov. 10, 1955.....	01:44:04	15°S	174°W	0.01R	7 to 7½	
Nov. 22, 1955.....	03:24:00	24½°S	123°W	0.00R	6¾ to 7	

TABLE I—*Concluded*

LIST OF THE EARTHQUAKES CONSIDERED

Date	H (G.M.T.)	Epicentre φ	Epicentre λ	Focal Depth	Magnitude	Remarks
Earthquakes for which solutions have been obtained—concluded						
Jan. 8, 1956......	20:54:13	19°S	70°W	0.00R	7½	
Jan. 10, 1956......	08:52:36	25°S	176°W	0.00R	7½	
Jan. 31, 1956......	09:17:11	4°S	152°E	0.06R	7 to 7½	
Feb. 1, 1956......	13:41:44	19°N	145½°E	0.05R	6¾ to 7	
Feb. 9, 1956......	14:32:40	31½°N	116°W	0.00R	6¾	
Feb. 18, 1956......	07:34:16	30°N	137½°E	0.07R	7¼ to 7½	
July 9A, 1956......	03:11:39	37°N	26°E	0.00R	7½	
July 9B, 1956......	09:56:13	20°N	73°W	0.01R	6½ to 6¾	
Earthquakes for which the data were sufficient but inconsistent						
Nov. 23, 1955......	06:29:29	50½°N	157°E	0.005R	7	Different Mechanism (?)
May 23, 1956......	20:48:30	15½°S	179°W	0.07R	7 to 7½	Different Mechanism (?)

and gives reasons for the failure: the second group lists earthquakes for which solutions were obtained: the third group consists of two earthquakes for which the data were sufficient but inconsistent. Two of the earthquakes listed in the Table occurred on the same date. The earlier has been called A, the later B.

In the earthquakes of the third group one circle could be defined for each earthquake but the second circle could have been drawn in either of two quite different positions. No justification could be found for selecting one position rather than the other, since both involved sacrificing a small group of reliable stations. The distribution of data in these unsolved 'quakes may indicate a mechanism more complex than failure under a couple. To facilitate additional study of this problem, first motion data, epicentral distances, and azimuths are given in Table II for all stations recording the two earthquakes. It is interesting to note that the earthquake of Nov. 23, 1955, occurred at a focal depth of 60 km. in the Kamchatka region where five similar unsolved earthquakes took place in 1953, (Hodgson, 1956). The shock of May 23, 1956, was the first of this type in the Fiji Islands.

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TABLE II

Distance, Azimuth and First Motion Data for Two Anomalous Earthquakes

A negative sign indicates an azimuth measured west of north

Earthquake	Nov. 23, 1955			May 23, 1956		
Station	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion
Aberdeen	71.2	− 12.0	C	138.4	+ 2.4	C_1'
			CC			CC
Abuyama	—	—	—	66.3	− 40.0	C
Alberni	—	—	—	80.3	+ 32.8	D
Alger	—	—	—	159.0	− 4.6	C_1'
						D_2'
Alicante	89.5	− 17.7	C	157.3	+ 2.9	C_1'
						CC
Almeria	91.1	− 16.5	D	158.6	+ 7.5	D_1'
Angra do Heroismo	—	—	—	146.1	+ 41.7	C_1'
Apia	—	—	—	7.3	+ 77.0	C
Arcata	—	—	—	76.0	+ 40.0	C
Ashkhabad	—	—	—	125.0	− 54.4	C_1'
Astrida	115.0	− 61.5	D_1'	146.1	−120.3	C_1'
						cC_1'
						cCC
Athens	82.7	− 35.7	C	150.1	− 38.1	C_1'
Auckland	—	—	—	22.0	−166.6	D
						DD
Bandung	71.3	−127.6	C	—	—	—
Banff	—	—	—	86.5	+ 34.4	C
Barrett	63.6	+ 70.2	C	—	—	—
Basel	78.9	− 20.7	C	147.8	− 8.6	C_1'
Belgrade	77.7	− 30.2	D	146.6	− 25.9	C_1'
Bensberg	—	—	—	144.5	− 6.8	C_1'
Berkeley	56.6	+ 69.6	C	75.3	+ 43.4	C
Bermuda	89.5	+ 34.1	C	118.8	+ 61.3	D
Bologna	80.8	− 24.4	D	149.8	− 6.5	C_1'
						cC_1'
Boulder City	62.2	+ 66.5	C	79.5	+ 48.0	C
Bozeman	57.8	+ 55.9	C	86.4	+ 40.6	C
Butte	56.9	+ 56.4	C	85.7	+ 39.9	C
Cartuja	91.1	− 15.6	C	158.1	+ 9.9	D_1'
			DD			C_2'
			CCC			dD_1'
			PcP=D			CC
Cheb	—	—	—	144.5	− 13.0	C_1'
						DD
						cCC
Chihuahua	72.7	+ 66.0	D	83.3	+ 57.7	C
Christchurch	95.0	+168.5	D	28.8	−167.5	D
Clermont	—	—	—	150.1	− 3.1	C_1'
Cleveland	—	—	—	105.8	+ 50.8	D
						dD
						D_1'
Cobb River	—	—	—	26.4	−165.9	D
						cC
Coimbra	88.8	− 11.2	D	154.2	+ 16.5	C_1'
						C_2'
College	31.8	+ 42.3	C	—	—	—
Collmberg	73.9	− 22.8	C	143.4	− 12.9	C_1'
						CC

TABLE II—*Continued*

Distance, Azimuth and First Motion Data for Two Anomalous Earthquakes

A negative sign indicates an azimuth measured west of north

EARTHQUAKE	Nov. 23, 1955			May 23, 1956		
STATION	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion
Columbia	81.7	+ 45.3	C	105.2	+ 58.4	C
Copenhagen	70.1	− 20.6	D	139.2	− 10.2	C_i'
						dD_i'
						CC
Corvallis	—	—	—	77.4	+ 39.0	C
De Bilt	74.9	− 17.8	C	143.6	− 4.6	C_i'
						dD_i'
						DD
Djakarta	71.1	−126.5	C	73.1	− 91.8	C
Durham	73.6	− 13.1	C	140.9	+ 2.2	C_i'
			CC			DD
Eureka	59.2	+ 64.3	C	80.3	+ 44.6	C
Fayetteville	—	—	—	95.1	+ 53.9	D
Florence	81.6	− 24.6	C	150.8	− 15.5	C_i'
Florissant	73.1	+ 48.8	D	—	—	—
			PcP = C			
Fresno	58.8	+ 69.0	C	76.4	+ 45.5	C
Frunse	54.3	− 64.2	C	112.5	− 49.9	C
Fukuoko	25.9	−121.2	C	68.6	− 43.8	C
Goris	71.8	− 49.8	C	134.0	− 49.9	C_i'
Guadalajara	—	—	—	82.7	+ 66.1	C
Halifax	78.8	+ 28.2	C	119.0	+ 47.1	C_i'
Hawaii	46.0	+112.6	C	42.3	+ 30.4	C
Helwan	—	—	—	148.7	− 58.2	C_i'
Hermanus	—	—	—	127.2	−161.1	DDD
Hong Kong	43.7	114.4	C	75.4	− 61.8	C
Honolulu	—	—	—	42.3	+ 30.4	C
Horseshoe Bay	—	—	—	81.2	+ 33.3	C
Hungry Horse	54.6	+ 55.1	C	—	—	—
Irkutsk	32.4	− 66.4	C	94.1	− 37.0	C
Isabella	60.3	+ 69.0	C	—	—	—
Istanbul	—	—	—	144.9	− 38.7	D_i'
Jerusalem	83.4	− 47.2	D	144.9	− 56.9	D_i'
Jujhno-Sakhalinsk	10.0	−105.0	C	—	—	—
Kaimata	—	—	—	28.2	−165.1	D
						cC
Karapiro	90.0	+165.3	C	22.8	−168.9	D
						cC
Karlsruhe	77.2	− 20.9	D	146.3	− 9.2	C_i'
			PcP = D			dD_i'
						DD
Kew	76.5	− 14.6	C	144.3	+ 1.4	C_i'
						DD
Kirkland Lake	70.2	+ 36.6	C	107.6	+ 44.0	CC
Kirovabad	—	—	—	133.6	− 48.5	C_i'
Kiruna	57.6	− 18.2	C	126.5	− 9.2	C_i'
Kochi	24.3	−126.1	C	66.6	− 42.4	C
Ksara	81.2	− 46.5	C	143.7	− 54.0	C_i'
			CC			
La Paz	130.7	+ 62.9	D_i'	104.8	+112.0	D
			CC			dD
						DD

TABLE II—*Continued*

Distance, Azimuth and First Motion Data for Two Anomalous Earthquakes

A negative sign indicates an azimuth measured west of north

Earthquake	Nov. 23, 1955			May 23, 1956		
Station	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion
La Plata	150.4	+ 71.2	D_i'	—	—	—
Lembang	71.4	−127.6	C	72.0	− 92.6	C
Lisbon	90.3	− 10.9	D	155.3	+ 19.0	C_i'
						cC_i'
						dD_i
Lwiro	—	—	—	147.2	−120.7	C_i'
						cC
						CC
						cCC
Macquarie Island	—	—	—	42.3	−161.2	D
						cC
						CC
						DDD
Malaga	91.7	− 15.0	D	158.5	+ 11.5	D_i'
			CC			D_i
			DDD			
Manila	46.3	−128.0	D	66.5	− 66.5	C
Manzanillo	—	—	—	81.3	+ 67.4	C
Matsushiro	19.7	−129.2	C	65.6	− 36.9	C
Mazatlan	—	—	—	80.9	+ 62.8	C
M'Bour	115.3	− 6.5	CC	—	—	—
Melbourne	88.8	−170.7	C	38.7	−132.0	D
						dD
Merida	87.9	+ 59.0	D	95.1	+ 69.7	C
Messina	85.3	− 29.7	C	154.2	− 27.2	C_i'
Mineral	55.5	+ 66.8	C	77.1	+ 41.5	C
Miyako	—	—	—	66.0	− 32.2	C
Miyazaki	—	—	—	66.9	− 44.7	C
Monaco	82.5	− 22.0	C	151.6	− 10.2	C_i'
Moscow	62.8	− 33.9	D	—	—	—
Mount Hamilton	57.4	+ 69.7	C	75.4	+ 44.2	C
						dD
Nagoya	—	—	—	65.5	− 38.9	C
Neuchatel	79.4	− 20.5	C	148.6	− 8.0	C_i'
New Plymouth	—	—	—	24.3	−167.0	D
Noumea	73.5	+170.7	C	—	—	—
			dD			
			PcP=D			
			pPcP=C			
Oaxaca	—	—	—	87.5	+ 71.8	C
Ottawa	74.1	+ 35.6	C	110.3	+ 46.8	C
Palisades	78.4	+ 36.8	C	111.5	+ 51.7	C
			CC			cC
						C_i'
						CC
Palo Alto	—	—	—	75.1	+ 43.6	C
Palomar	63.0	+ 70.0	C	—	—	—
Pasadena	61.7	+ 70.1	C	76.2	+ 48.1	C
Pavia	80.6	− 22.6	C	149.8	− 11.5	C_i'
						cC_i'
Perth	—	—	—	60.8	−118.2	D
						cC

TABLE II—*Continued*

Distance, Azimuth and First Motion Data for Two Anomalous Earthquakes

A negative sign indicates an azimuth measured west of north

EARTHQUAKE	Nov. 23, 1955			May 23, 1956		
STATION	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion
Pittsburgh	76.6	+ 41.2	C	106.7	+ 51.9	D
Prague	—	—	—	144.0	− 15.0	C'
Quetta	67.4	− 70.0	C	118.3	− 64.3	C' cC
Rabaul	—	—	—	30.2	− 71.4	C
Rapid City	—	—	—	90.9	+ 44.4	D
Rathfarnham	—	—	—	142.2	+ 7.0	D' cC' DD
Relizane	—	—	—	160.2	+ 1.1	D'
Reno	57.0	+ 66.6	C	77.7	+ 42.9	C
Resolute	56.4	+ 20.6	C	103.3	+ 15.8	C
Reykjavik	65.8	− 0.8	D	129.0	+ 12.7	C'
Riverside	62.1	+ 69.7	C	—	—	—
Riverview	84.2	−175.2	C PcP=D	32.5	−129.3	D dD
Rome	—	—	—	152.1	− 18.7	C'
Saint Louis	73.4	+ 48.8	D PcP=C	98.8	+ 52.3	D dD CC
Salt Lake City	60.7	+ 60.7	C	83.7	+ 44.8	C
San Juan	—	—	—	116.3	+ 76.8	C'
Santa Clara	—	—	—	75.2	+ 43.9	C
Sapporo	13.2	−119.5	C	68.7	− 30.3	C
Scoresby Sund	59.3	− 0.6	D	123.4	+ 9.0	D'
Seattle	50.6	+ 60.0	C	80.9	+ 35.0	C
Semipalatinsk	46.8	− 59.3	C	108.6	− 41.6	C
Sendai	—	—	—	65.3	− 33.9	C
Seven Falls	74.3	+ 31.7	D	—	—	—
Shasta	54.8	+ 66.9	C	76.9	+ 40.8	C
Shawinigan Falls	—	—	—	112.5	+ 45.6	C CC
Skalnate Pleso	74.0	− 28.1	D	143.1	− 21.4	C'
Skalstugan	—	—	—	131.6	− 7.0	C'
Spring Hill	81.0	+ 52.2	C	—	—	—
Stara Dala	75.7	− 27.4	D	144.9	− 20.5	C'
State College	77.2	+ 39.7	D	108.4	+ 51.8	D CC
Strasbourg	77.8	− 20.6	C	146.8	− 8.4	C' cC' CC dDD
Stuttgart	77.2	− 21.4	C	146.4	− 10.1	C'
Tacubaya	84.0	+ 67.1	D	86.0	+ 68.6	C
Takamatsu	—	—	—	66.7	− 41.3	C
Tamanrasset	—	—	—	171.7	− 30.3	C'
Tashkent	58.3	− 62.7	C CCC	—	—	—
Tinemaha	59.5	+ 67.7	C	—	—	—
Tokyo	19.6	−133.8	C	64.1	− 36.7	C
Toledo	88.5	− 14.7	C	155.4	+ 9.1	C'
Tongariro	—	—	—	24.2	−171.1	D

TABLE II—*Concluded*

Distance, Azimuth and First Motion Data for Two Anomalous Earthquakes

A negative sign indicates an azimuth measured west of north

EARTHQUAKE	Nov. 23, 1955			May 23, 1956		
STATION	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion
Trieste	79.0	− 25.5	C	148.4	− 17.0	C'_i
Tsukuba	—	—	—	64.4	− 36.0	C
Tuai	—	—	—	23.3	−172.7	C
Tucson	67.3	+ 66.9	C	80.9	+ 52.9	C
Uccle	—	—	—	144.9	− 3.8	C'_i
Ukiah	—	—	—	75.4	+ 41.8	C
Uppsala	65.2	− 21.4	C	134.3	− 11.9	C'_i
Uvira	—	—	—	146.2	−121.9	C'_i CC
Vera Cruz	—	—	—	88.8	+ 69.9	C
Victoria	49.5	+ 59.7	C	80.8	+ 33.9	C
Vienna	76.0	− 26.2	C	145.1	− 18.2	C'_i
Wellington	93.2	+166.6	C	26.2	−169.4	D
Weston	78.3	+ 34.3	C cC	—	—	—
Witteveen	—	—	—	142.8	− 5.8	C'_i DD
Woody	60.1	+ 69.3	C	—	—	—
Zagreb	78.1	− 26.8	C	—	—	—

The data on which the 15 solutions are based are given in Table III. The notation in Tables II and III is the same as in previous papers.

TABLE III

Data on which the Solutions are Based

Station	Aug. 16, 1955	Aug. 21, 1955	Aug. 28, 1955	Sept. 12, 1955	Oct. 13, 1955	Nov. 10, 1955	Nov. 22, 1955	Jan. 8, 1956	Jan. 10, 1956	Jan. 31, 1956	Feb. 1, 1956	Feb. 9, 1956	Feb. 18, 1956	July 9A, 1956	July 9B, 1956
Aberdeen	CC	(CC)	(D)	(C) DDD	—	(C_1') (DD)	CC	—	(D_2')	—	—	—	C (CC) DDD	C	D CC
Abuyama	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—
Aikawa	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Ajiro	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Akita	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Alger	—	—	—	—	C_1'	—	—	D	—	—	—	—	—	—	D
Alicante	C_1' (cC_1')	C_1'	—	D	—	D_1'	—	(C)	(C_1')	D_1'	(C_1')	D	(C)	C	—
Almeria	(D_1')	C_1'	D	D	(D_1')	D_1'	—	(C)	D_1'	D_1'	(C_1') (DD)	(C) (CC)	(C) (CC)	—	(C)
Angra do Heroismo	—	—	(C)	—	—	—	—	—	—	—	—	—	—	(D)	—
Aomori	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Apia	(C)	—	—	C_2'	C cC DD	D	(C)	—	C	C	—	C	C	D_2'	—
Ashkhabad	—	—	—	—	—	—	—	—	—	—	—	—	D	—	—
Astrida	C_1'	—	C_1'	C	C_1' DD	—	—	(DD)	D_1'	D_1'	D_1'	C_1'	(C) CC	D	CC
Athens	(D_1')	—	—	D	C_1'	D_1'	C_1'	—	—	—	—	—	—	C	(C)
Auckland	—	—	—	—	C	C	—	—	D	—	—	—	D	—	—
Bandung	—	—	—	—	—	—	—	(C_1')	—	—	—	—	D	—	—
Banff	D	—	C	C	C	D	D	C	—	D	D	D	—	—	—
Barcelona	—	—	—	—	—	—	—	—	—	—	—	D	—	—	—
Barrett	D	—	—	—	C	—	D	—	—	—	—	D	—	—	—
Basel	(D_1')	C_1'	(D)	D	C_1'	D_1'	—	D	D_1'	—	D	C	(C)	C	D
Belgrade	C_1'	—	C	D	(D_1')	D_1'	C_1'	—	D_1'	—	—	(C)	D	(D)	D
Bensberg	—	—	—	D	—	—	—	D	—	—	D	—	—	—	—
Berkeley	D	C	C	—	C	(C)	D	C	C	D	D (dD)	D	C	(CC)	D
Bermuda	—	—	(C)	C	C_1'	D_1'	(C)	D	—	—	—	C	—	C	C
Besancon	—	—	—	—	—	—	D	—	—	—	—	—	—	—	—
Big Bear	—	—	—	—	—	—	—	—	—	—	—	D	—	—	—
Bologna	—	—	—	D	—	—	—	—	—	—	—	—	—	C	—
Boulder City	D	—	C	C	C	D	(C)	C	C	D	D	D	C	D	D
Bozeman	D	—	C	(D)	C	D	(C)	C	(D)	D	D	D	C	(C)	D
Bucarest	—	—	—	C	—	(C_1')	C_1'	—	—	—	—	—	—	—	—
Butte	(C)	C	C	C	C	(C)	D	C	C	D	(C)	D	C	D	D
Cartuja	(D_1') dD_1' CC	(D_1') DD cCC CCC	(C) CC DDD (PcP=D)	—	C_1' (CC)	(C_1') dD_1' (DD)	—	(C)	D_1' (D_2') DD	—	—	(C)	(CC) dDD (DDD) dDDD	D	(C) (CC) (PcP=D)

TABLE III—*Continued*

Data on which the Solutions are Based

Station	Aug. 16, 1955	Aug. 21, 1955	Aug. 28, 1955	Sept. 12, 1955	Oct. 13, 1955	Nov. 10, 1955	Nov. 22, 1955	Jan. 8, 1956	Jan. 10, 1956	Jan. 31, 1956	Feb. 1, 1956	Feb. 9, 1956	Feb. 18, 1956	July 9A, 1956	July 9B, 1956
Cheb	—	—	—	—	—	—	—	—	—	—	D CC	—	D (dD) DD (DDD)	—	—
Chicago (U.S.C.G.S.)	—	—	—	—	—	—	—	—	D	—	—	—	—	—	D
Chichibu	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Chihuahua	—	—	—	—	—	—	D	C	—	—	—	(C)	DD	(CC)	—
China Lake	—	—	—	—	C	—	—	—	—	—	—	—	—	—	—
Chinchina	—	—	—	—	—	—	—	D	—	—	—	—	—	—	—
Christchurch	—	—	—	—	C (DDD)	—	D	—	C	—	—	—	D	—	—
Chosni	—	—	—	—	—	—	—	—	—	—	—	—	D	—	—
Clermont	—	—	—	—	—	—	—	—	—	—	—	—	—	C	D
Cleveland	C_1' cC CC	C_1'	—	C	(D_1') (CC)	D CC	(C)	D	—	—	D_1' (DD)	C	(D) (dD)	C	—
Cobb River	C	D	—	C_1'	C	—	—	—	—	—	—	—	—	—	—
Coimbra	C_1'	—	D	D	C_1' C_3'	(C_1') (C_3')	—	D	DD	—	—	C	—	C	D
College	C	—	C	(D)	(D)	D	C	C	C	D	D	D	C	—	D
Collmberg	—	—	—	—	(D_1')	—	—	(C) (CC)	—	—	D CC	(C) (CC)	D DD	—	D (DD)
Columbia	—	—	—	C	C	—	—	D	—	—	D_1'	C	—	—	D
Comitan	—	—	(D)	—	—	D	—	—	—	—	—	D DDD	—	(CC)	—
Copenhagen	C_1'	DD	C CC	—	—	(cC_1') (DD)	DDD	(C) DD	D_1'	—	D (DD) (dD)	D	D (dD) DD	C	(C)
Corvallis	—	—	—	—	—	—	—	—	—	—	—	D	—	—	—
Dalton	—	—	—	—	—	—	—	—	—	—	—	D	—	—	—
De Bilt	—	—	—	D	C_1'	(C_1')	—	D	D_1'	—	—	D	D	C	D
Djakarta	D	C	C_1'	C	C	C	—	D_1'	D	—	D	—	D	(C)	—
Durham	(D_1') (DD) (dDD)	DD	(D)	D	—	D_1'	—	—	—	—	—	—	(C)	C (PcP=C)	D
Eureka	(C)	—	C	C	C	D	D	C	—	D	D	D	C	—	D
Fayetteville	—	—	—	—	—	—	—	(D)	—	D	(C)	—	—	—	—
Florence	C_1' (cC_1') (DD)	—	—	—	—	D_1'	—	D	—	—	D	—	(C)	—	D
Florissant	—	C_1' (DD)	(C) (dDD)	(D) (DD)	C_1' DD	D (DD)	D	—	D (DD)	—	(C) (dD) (DD)	C	—	—	(C)
Fort Tejon	—	—	—	—	—	—	—	—	—	—	—	D	—	—	—

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Fresno	D	—	C	—	C	—	D	C	C	D	D	D	C	—	—
Frunse	D (cC)	—	—	—	C	—	—	—	—	—	D (dD)	—	(C)	—	—
Fukuoko	D	—	—	C	—	—	—	—	D	—	D	—	C	—	—
Fukushima	—	—	—	—	—	—	—	—	—	—	—	D	—	—	—
Funatsu	—	—	—	—	—	—	—	—	—	—	D	—	D	—	—
Goris	—	—	—	—	—	—	—	D'_i DD	—	—	D cC	—	(C) cC	—	D (DD)
Grahamstown	—	—	—	C	—	—	—	D	—	—	—	(C'_i)	—	(C)	—
Guadalajara	—	—	D	—	—	—	—	—	—	—	—	D	—	—	—
Hachijo-Jima	—	—	—	—	—	—	—	—	—	—	—	—	(C)	—	—
Halifax	C'_i dD'_i	C'_i	D DD CCC	—	C'_i	—	—	C	—	—	(C'_i)	(D)	DD	C	—
Hamada	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Hamburg	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—
Hatinohe	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Hawaii	D	D	C	—	C	(C)	(D)	—	—	D	—	—	(C)	—	—
Helsinki	—	—	—	—	—	—	—	—	—	—	—	—	—	(D)	—
Helwan	—	—	—	—	C'_i	—	—	—	—	D'_i	D	—	—	D	D
Hermanus	—	—	CC	C	—	—	—	(C)	—	—	CC (CCC)	—	—	—	—
Hiroshima	—	—	—	(D)	—	—	—	(CC)	—	—	D	—	—	D	—
Hong Kong	D (cC)	C	—	—	C	—	—	—	D	D	D CC	—	D	—	—
Honolulu	D	D	(D)	—	—	—	—	—	(D)	—	D	—	—	—	C
Horseshoe Bay	D	—	C	—	C	—	C	(D)	—	D	D	D	C	D	D
Hungry Horse	(C)	C	C	C	C	D	(C)	C	C	D	D	D	C	D	D
Inawashiro	D	—	—	—	—	—	—	—	—	—	D	—	C	—	—
Irkutsk	D	(D)	—	C	C	D	D'_i	D'_i	—	D	D	—	C	D	—
Isabella	—	D	—	—	C	—	—	—	—	—	—	D	—	—	—
Istanbul	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(C)
Izuhara	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—
Jerusalem	—	—	—	(C)	—	(C'_i)	—	(C'_i)	—	—	(C)	—	(C)	(C)	—
Jujhno-Sakhalinsk	D	C	(D)	C	C	D	D'_i	D'_i	C	D	D	—	C	D	D
Kagoshima	—	—	—	—	—	—	—	—	—	—	D	—	C	—	—
Kaimata	—	—	—	C'_i	C	(D)	—	—	D	D	(C)	—	(C)	—	—
Kameyama	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Karapiro	C	D	—	C'_i	C	C	—	—	—	D	D	—	D	—	—
Karlsruhe	C'_i (DD)	DD	C (cC)	D	C'_i (CC)	D'_i (cC'_i) (DD)	(D'_i)	D (CC)	—	D'_i	(DD) (dD) (cCC)	D	D (dD)	C	D
Kew	C'_i (cC'_i)	(D'_i) DD	C (DD)	D	C'_i	D'_i (DD)	C'_i	D (dD) DD cCC CCC	D'_i	D'_i	D (DD) (CCC)	C	D (dD) (CC)	C	D dD (CC)
Kimberley	—	—	C'_i	(D)	(D'_i)	—	(D'_i)	(C)	—	(C'_i)	(C'_i)	(C'_i)	—	(C)	—
Kirkland Lake	C'_i CC cCC	C'_i	C	C (cC)	—	—	(C)	D	—	D'_i	—	C	C (dD) (CC)	C	D
Kirovobad	—	C	—	(D)	—	—	—	—	—	—	—	—	—	D	D

TABLE III—*Continued*

Data on which the Solutions are Based

Station	Aug. 16, 1955	Aug. 21, 1955	Aug. 28, 1955	Sept. 12, 1955	Oct. 13, 1955	Nov. 10, 1955	Nov. 22, 1955	Jan. 8, 1956	Jan. 10, 1956	Jan. 31, 1956	Feb. 1, 1956	Feb. 9, 1956	Feb. 18, 1956	July 9A, 1956	July 9B, 1956
Kiruna	—	DD	C	C	C	—	C_1' (DD)	—	—	D_1'	D	(C)	C DD CCC	C	D
Kizil-Arvat	—	—	—	—	—	—	—	—	—	—	—	—	—	(C)	—
Kochi	—	—	—	—	—	—	—	—	—	—	D	—	C	—	—
Kofu	—	—	—	—	—	—	—	—	—	—	D	—	C	—	—
Ksara	C_1' CC (dDD)	C	(D)	—	(D) (CC)	D_1' dD_1' cCC	(D_1') C_2' CC	DD CCC	(C_2') CC	—	D (DD) cC	—	D (dD)	(C) DDD	(C) CC
Kumagaya	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Kumamoto	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
La Paz	C_1' DD	C_1' DD	(C) CC	—	C_1' (CC)	(D_1')	(D)	(D)	—	D_1' (DD)	D_1' (dD_1') (DD)	(C)	D_1' (cC_1')	D DD	C cC (CC) (cCC)
La Plata	—	C_1'	—	—	—	C_1'	—	D	—	—	—	—	D_1'	—	—
Lembang	D	—	C_1'	C	C	C	—	D_1'	—	D	—	—	D	D	C_1'
Lisbon	(D_1') CC	—	—	D	(D_1') C_2'	D_1' (C_2')	—	D DD	—	D_1'	(DD)	D	—	C (dD)	D
Lwiro	(D_1') (DD) (CCC)	(CC)	C_1'	C	C	—	C_1'	(DD)	(C_1')	D_1'	D_1'	C_1'	D (C_1') cC	D	C CC
Macquarie Island	C	—	—	—	—	—	—	—	(C)	—	—	—	(C)	—	—
Madras	—	—	—	—	—	—	—	—	—	—	—	C_1'	—	—	—
Maebashi	—	—	—	—	—	—	—	—	—	—	D	—	—	D	—
Malaga	C_1' (DD)	C_1' (CC) (DDD)	D CC	(C) PcP=C	C_1' (CC) CCC	D_1' (C_1') (DD)	—	D	D_1' (D_2') DD	D_1' (DD)	D_1' CC (CCC)	D DD CCC	(CC)	C (PcP=C)	D DD (DDD) PcP=D
Manila	D	—	—	C	C	—	—	—	—	D	—	—	D	—	—
Manzanillo	—	—	—	—	—	—	—	—	—	—	—	D	—	—	—
Matsumoto	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Matsushiro	D (dDD)	D	—	C	C	D	—	D_1'	—	D	D	C	C	D	C_1'
Mazatlan	—	—	—	—	—	—	—	C	—	—	—	D	—	—	—
M'Bour	C_1' (DD)	(D_2')	(cC)	D (cC)	C_1' C_2' DD	C_1' D_2' CC	—	D	(CC)	—	D_1'	D	D_1'	(D)	D
Melbourne	—	D	—	—	C	C	D	—	—	D CC dD	D cC (PcP=C)	—	D (CC) (PcP=C)	—	—
Merida	(D_1')	CC	D	—	—	D	—	D	—	—	—	D	—	(C)	C
Messina	—	—	—	D	C_1'	D_1'	—	—	—	—	—	—	D	C	—

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Messstetten	—	—	—	(C)	—	—	—	—	—	—	—	—	—	C	—
Mineral	D	—	C	C	C	—	D	C	C	—	—	D	C	—	D
Mishima	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Mito	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Miyako	—	—	—	—	C	—	—	—	—	—	—	—	C	—	—
Miyasaki	—	—	—	—	—	—	—	—	—	—	D	—	C	—	—
Monaco	—	—	—	—	—	—	—	—	—	(C'_1)	—	—	—	—	D
Montreal	—	—	—	—	—	—	—	—	—	—	—	—	—	(D)	(C)
Mori	—	—	—	(D)	—	—	—	—	—	—	D	—	—	—	—
Morioka	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Moscow	(C)	(D)	C	C	C	D'_1	—	(C'_1)	—	(C)	D	D	C	C	—
													(dD)		
Mount Hamilton	D	C	(D)	—	C	(C)	D	C	C	D	D	D	C	D	D
													cC		
Muroran	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Murotemisaki	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Nagano	D	—	—	C	—	—	—	—	—	—	D	—	—	—	—
Nagasaki	—	—	—	—	—	—	—	—	—	—	D	—	—	D	—
Nemuro	—	—	—	C	—	—	—	—	—	—	D	—	—	—	—
Neuchatel	—	C'_1	C	D	—	D'_1	—	D	—	D'_1	—	—	D	—	D
New Plymouth	(D)	—	—	—	C	—	—	—	—	—	—	—	—	—	—
Noumea	C	C	—	—	C	C	—	(CC)	D	D	—	—	D	—	—
	cC	CCC								DDD					
		PcP=C													
Oaxaca	(DD)	—	D	—	—	D	—	C	—	—	—	—	—	—	—
Oita	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Omaezaki	—	—	—	—	(D)	—	—	—	—	—	D	—	D	—	—
Onahama	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Osaka	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Oshima	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Ottawa	—	(D'_1)	—	C	C'_1	—	D	D	—	D'_1	—	C	C	C	D
Palisades	C'_1	C'_1	C	C	C'_1	D	D	D	(DD)	D	D	C	cC	(D)	D
	(cC'_1)		DD		(CC)	(cC)					CC			(CC)	
	CC					(DD)					(CCC)			CCC	
Palo Alto	—	(DD)	(D)	—	—	—	—	—	—	D	D	D	—	—	D
Palomar	—	—	C	—	C	—	—	—	—	—	—	D	—	—	—
Paris	—	—	(D)	D	—	—	—	—	D'_1	—	D	—	—	—	—
Pasadena	D	D	C	—	C	D	D	C	D	D	D	D	D	D	D
Pavia	—	—	C	D	—	D'_1	—	—	—	—	—	—	—	C	D
Perth	(PcP=D)	C	—	—	C	—	—	—	—	—	—	—	D	D	—
														(DD)	
Philadelphia	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—
Pietermaritzburg	—	—	—	C	—	—	—	D	—	—	D'_1	—	—	D	—
Pittsburgh	—	—	—	(D)	—	—	—	—	—	—	—	C	—	—	—
Prague	—	—	—	D	—	D'_1	—	(C)	—	—	D	—	D	(D)	—
Pretoria	—	—	—	—	—	—	—	D	—	D	(C'_1)	D'_1	—	(C)	—
Pulkovo	—	—	—	—	—	—	—	—	—	—	—	D	—	—	—
Punta Arenas	—	—	—	—	—	—	—	D	—	—	—	—	—	—	—
Quetta	D	PcP=C	C'_1	D	C	C'_1	D'_1	D'_1	D'_1	D	D	C	D	D	C'_1
	CC		(cC'_1)		(CC)			CC		(DD)			(cC)		CC
	(PcP=C)		DD												
Rapid City	—	—	—	—	—	—	—	—	—	—	—	—	—	(C)	(C)

TABLE III—*Continued*

Data on which the Solutions are Based

Station	Aug. 16, 1955	Aug. 21, 1955	Aug. 28, 1955	Sept. 12, 1955	Oct. 13, 1955	Nov. 10, 1955	Nov. 22, 1955	Jan. 8, 1956	Jan. 10, 1956	Jan. 31, 1956	Feb. 1, 1956	Feb. 9, 1956	Feb. 18, 1956	July 9A, 1956	July 9B, 1956
Rathfarnham	(D'_i) dD'_i CC DDD	(D'_i) (CC)	(D)	D	C'_i (CC)	D'_i	—	D (dD) (CC)	(C'_i)	D'_i	D	C DD	D (dD) (CC)	C	D
Reggio Calabria	—	—	—	(C)	—	—	—	—	—	—	—	—	—	(D)	—
Relizane	—	—	—	D	—	—	—	—	—	—	—	—	—	—	D
Reno	D	—	C	—	C	—	D	C	—	D	D	D	C	—	—
Resolute	—	C	C	(D)	(D)	D (DD)	—	—	—	D	D	D	C	D	(D)
Reykjavik	C'_i	—	C dD	D	C'_i	D'_i	—	D	—	D'_i	D	—	C	(D)	(C)
Riverside	—	—	C	—	C	—	—	—	—	—	—	D	—	—	—
Riverview	(D) (cC)	(C) cC	—	(D'_i) (cC'_i) DD CCC	C (cC)	C cC	D	DD	CC	D dD	D (dD)	C'_i	D dD (CC) (DDD) PcP=D	(C'_i) CC	—
Rome	—	—	—	D	C'_i	D'_i	—	(C)	D'_i	—	—	—	—	C	D (cC)
Saga	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Saint Louis	(D'_i) CC DDD	C'_i (DD)	D (CCC)	(D) (cC) (DD) cCC	C DD	(C) CC	D	C cC	CC	D'_i CC	D CC	(D)	C (dD) DD	C (CC)	(C)
Salo	—	—	—	(C)	—	(C'_i)	—	—	—	—	—	—	—	—	—
Salt Lake City	D	C	C	(D)	C	D	D	C	C	D	D	C	C	(C)	D
San Juan	—	C'_i	—	C	C'_i	—	D	D	—	—	(C'_i)	(C)	—	C	D
Santa Clara	dD	—	C	—	C	D	—	(D)	—	—	—	—	C	D	D
Santa Lucia	—	—	—	—	—	C	—	(C)	—	—	—	—	—	—	—
Sapporo	D	D	—	—	C	(C)	—	—	—	—	D	—	C	—	—
Scoresby Sund	—	—	(D) (DD)	—	—	—	—	(C)	—	—	(C) (dD)	(C)	—	(D)	(C)
Seattle	D	C CC	C	—	C	D (PcP=C)	C	C DD	—	D	D	(C)	C (CC)	D	D
Semipalatinsk	D	C	—	C	C	—	—	—	—	—	D	—	—	D	—
Sendai	—	—	—	—	—	—	—	—	—	—	D	—	C	—	—
Seven Falls	C'_i	—	—	C	C'_i	—	D	D	—	D'_i	—	C	—	C	D
Shasta	D	C	C	C	C	D	C	C	C	D	D	—	C cC	—	D
Shawinigan Falls	C'_i	—	—	—	—	—	(C)	D	—	—	—	(D)	(D) (dD)	C	D
Shillong	—	—	—	—	—	—	—	—	—	—	—	C'_i	—	—	—
Shimizu	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Shionomisaki	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—

Shizuoka	D	—	—	—	—	—	—	—	C	—	D	—	D	—	—
Simferopol	—	—	—	C	—	—	—	—	—	—	(C)	D	D	—	—
Sitka	—	—	—	—	—	—	—	—	—	—	—	—	—	D	(C)
Skalnate Pleso	C'_1	—	—	—	C'_1	(C'_1) dD'_1 (DD)	—	—	—	—	—	—	D	—	—
Skalstugan	—	—	—	—	—	—	—	—	—	—	—	—	C (dD)	(D)	D (DD)
Spring Hill	—	—	—	—	—	—	D	—	—	—	—	—	—	—	—
Stara Dala	—	DD	—	—	—	dD'_1 (DD)	—	DD CCC	—	—	—	—	D	—	—
State College	—	—	D (PcP=D)	—	—	—	—	(C)	—	—	—	—	(C'_1)	C	D
Strasbourg	C'_1 (cC'_1) CC (dDD)	—	C (cC) CC CCC	D	C'_1 (CC)	D'_1, dD'_1 CC	(D'_1)	D	(CC)	(C'_1)	D (DD)	D	D (dD) (dDD)	C	D
Stuttgart	C'_1	—	—	D (PcP=D)	—	D'_1	—	D	—	D'_1	D (DD)	(PcP=D)	(C) cC DD	C	D
Sumoto	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Suttsu	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Sverdlovsk	—	—	—	—	—	—	—	—	—	—	—	D	—	—	—
Tacubaya	(D'_1) (DD)	CC	D	—	DD	CC	—	C	D	—	—	(C)	—	(CC)	(D)
Takamatsu	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Tamanrasset	—	—	—	D	C'_1	(C'_2) dD'_2, C_1	—	D	—	D'_1	CC	—	—	D	D
Tananarive	(D)	—	—	(D)	—		—	—	—	(DD)	(C)	—	(C)	—	C'_1
Tashkent	D (cC) (DD)	C	C'_1	D	C	(C'_1)	—	(C'_1) CC	D'_1	D cC	D (CCC)	—	D	—	—
Tbilisi	D (DD)	(CC)	C CC	D	DD	D'_1	—	DD	D CC	D'_1	D cC (DD)	—	D	—	—
Tinemaha	—	—	—	—	C	—	D	—	—	—	—	D	—	—	—
Tokushima	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Tokyo	—	—	—	C	C	—	—	—	—	—	D	—	(C)	—	—
Toledo	—	—	—	—	C'_1	D'_1	—	D	—	—	—	—	—	—	D
Tomie	—	—	—	—	—	—	—	—	—	—	D	—	C	—	—
Tomizaki	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Tori-shima	—	—	—	—	—	—	—	—	—	—	D	—	D	—	—
Tortosa	—	—	—	—	—	—	—	—	—	—	—	D	—	—	—
Trieste	—	—	C	—	C'_1 (CC)	D'_1	—	—	—	—	—	—	—	C	—
Tuai	(D)	C	—	—	C	—	—	—	C	—	(C)	—	D	—	—
Tucson	D	—	D	—	C	D	D	C	—	D	D	C	D	D	D
Uccle	—	—	C	D	—	—	—	—	—	—	—	—	—	C	D
Ukiah	—	—	—	—	—	—	—	—	—	—	—	—	—	D	D
Uppsala	(DD)	DD	C dD	—	—	D'_1 dD'_1	—	—	—	D'_1	D	D	C (dD)	C	D CC
Urakawa	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Utsunomiya	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—

TABLE III—*Concluded*

Data on which the Solutions are Based

Station	Aug. 16, 1955	Aug. 21, 1955	Aug. 28, 1955	Sept. 12, 1955	Oct. 13, 1955	Nov. 10, 1955	Nov. 22, 1955	Jan. 8, 1956	Jan. 10, 1956	Jan. 31, 1956	Feb. 1, 1956	Feb. 9, 1956	Feb. 18, 1956	July 9A, 1956	July 9B, 1956
Uvira	—	—	—	—	—	—	—	—	—	D'_1	—	C'_1	D	—	C CC
Uwajima	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Vera Cruz	—	(DD)	D	—	—	(C)	—	C	—	—	—	—	—	—	—
Victoria	—	—	(D)	(D)	C	D	C	C	—	D	D cC	D	C (dD)	—	D
Vienna	—	—	—	D	—	D'_1	—	—	—	—	—	—	—	C	—
Warsaw	—	—	—	—	—	—	—	—	—	—	—	—	—	C	D
Washington	—	—	—	C	C'_1	—	—	D	—	—	—	(D)	—	(D)	D
Wellington	C	(C)	—	—	C dD (CC)	C	D	C	D	D	D	—	D	—	—
Weston	C'_1	C'_1	C	C	C'_1	—	—	(C)	—	—	—	C	(D)	(D)	D
Witteveen	—	—	—	—	—	—	—	—	—	—	—	—	—	C	D
Woody	D	D	—	—	C	—	D	—	—	—	—	D	—	—	—
Yaku-shima	—	—	—	—	—	—	—	—	—	—	—	—	D	—	—
Yokohama	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Zagreb	—	—	—	D	—	—	—	—	—	—	—	—	—	C	—
Zurich	C'_1	—	—	D	—	—	—	—	—	—	—	—	—	—	—

ANALYSIS OF THE DATA

The 15 solutions are treated individually in this section. A solution diagram showing a representative group of stations, a short discussion, and a table summarizing the inconsistencies for all phases are given in each case. Although reflected phases occur in the tables, it should be stressed that they did in no way influence the solutions; rather the solutions were used to test the accuracy of the reflected phases.

Earthquake of 11:46:58, Aug. 16, 1955. $\varphi = 6°S, \lambda = 155°E$

The solution for this earthquake is shown in Figure 1, and the score for the solution is given in Table IV. The score for the direct phases is poorer than usual. This is chiefly

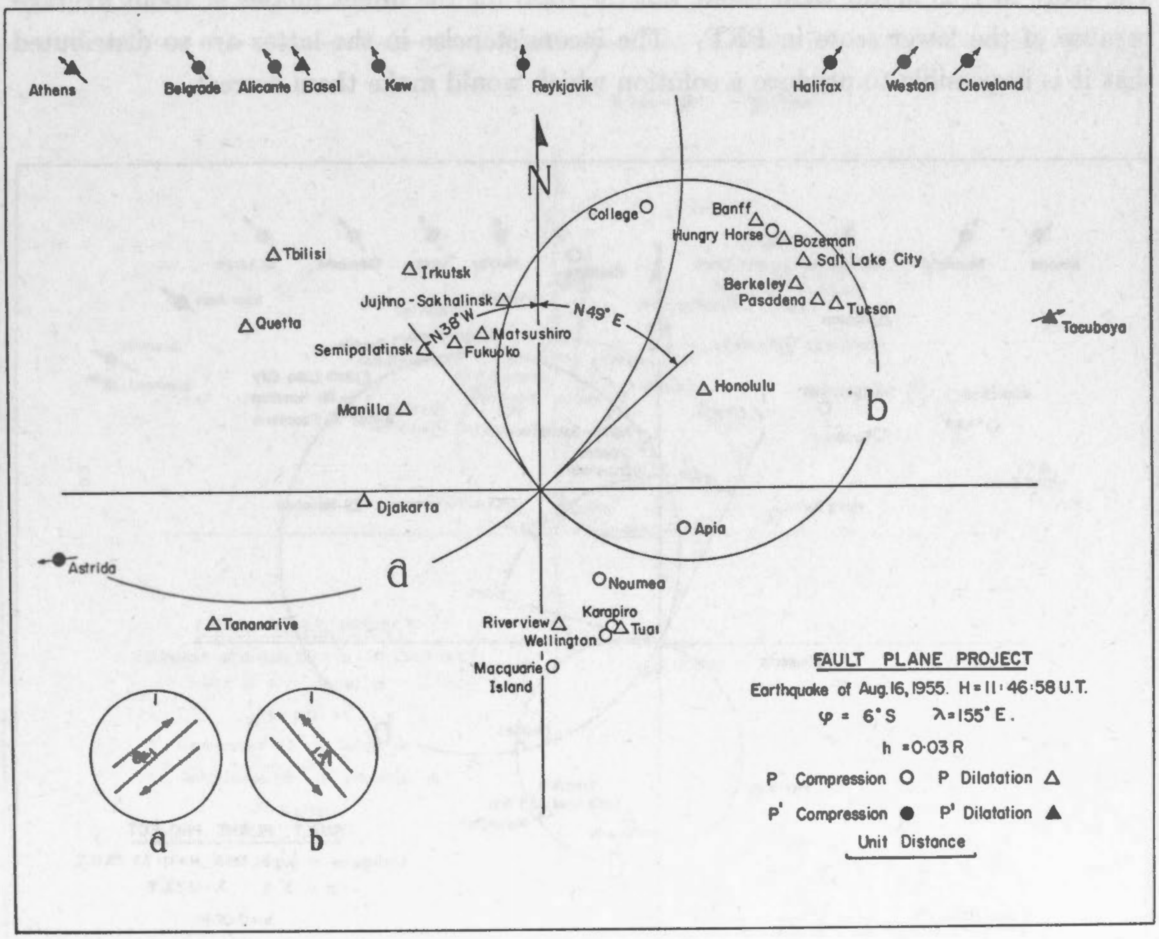

Figure 1

due to the large number of inconsistent observations of PKP. However these inconsistent observations of PKP are surrounded in most instances by consistent observations and do not introduce serious doubt about the solution.

TABLE IV

	Direct Phases			Reflected Phases						
	P	P$'_1$	Total	PP	pP	pP$'_1$	PPP	pPP	PcP	Total
Total Number of Observations......	49	35	84	24	7	8	3	5	2	49
Number of Inconsistent Observations	8	11	19	12	4	5	1	4	2	28

Earthquake of 17:33:58, Aug. 21, 1955. $\varphi = 3°S, \lambda = 137\frac{1}{2}°E$

Figure 2 gives the solution for this earthquake. The score is shown in Table V. The score in P is better than usual, but the total for the direct phases is about average because of the lower score in PKP. The inconsistencies in the latter are so distributed that it is impossible to produce a solution which would make them correct.

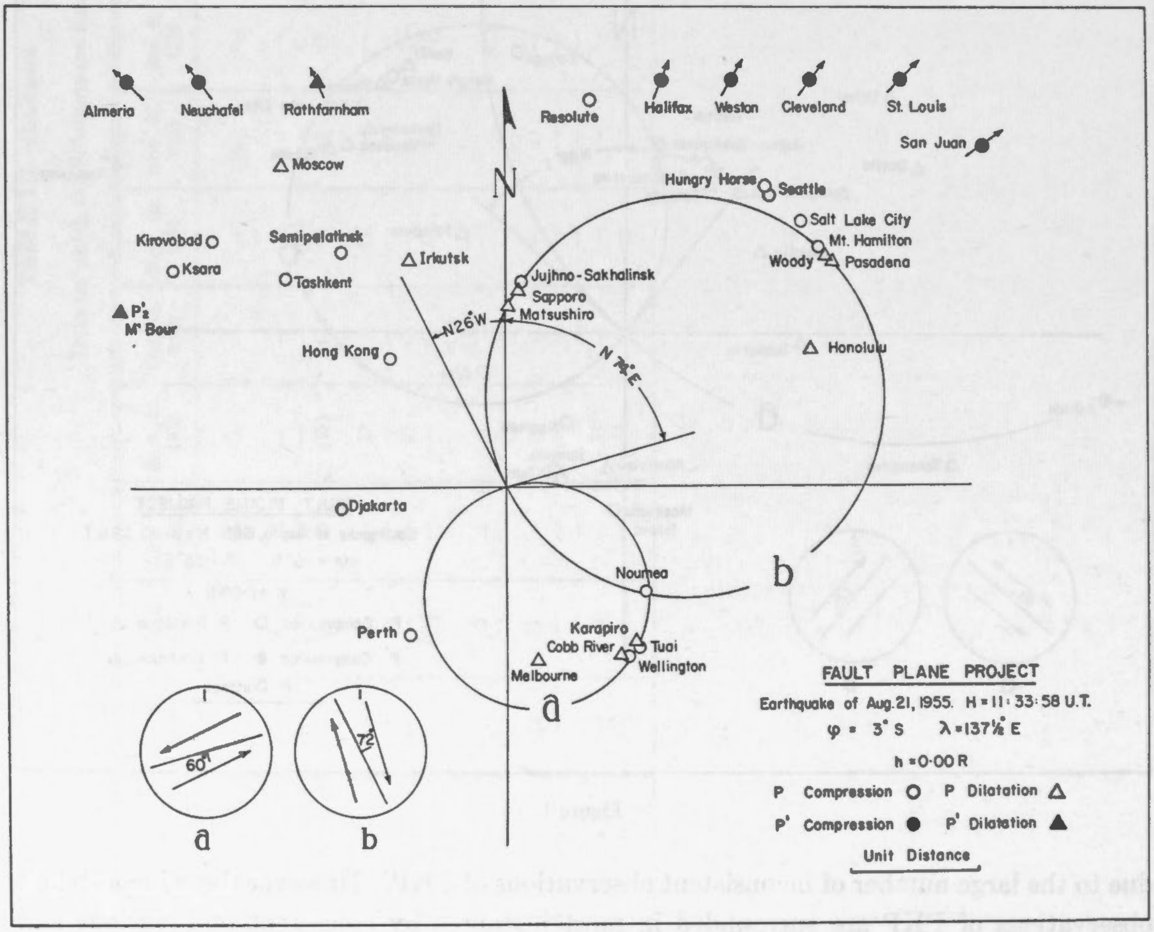

Figure 2

TABLE V

	Direct Phases				Reflected Phases					
	P	P_1'	P_2'	Total	PP	pP	PPP	pPP	PcP	Total
Total Number of Observations......	33	19	1	53	21	1	2	1	1	28
Number of Inconsistent Observations	4	4	1	9	9	0	1	0	0	10

Earthquake of 20:13:30, Aug. 28, 1955. $\varphi = 14°N$, $\lambda = 91°W$

The solution for this earthquake is shown in Figure 3. As shown in Table VI there is a very high percentage of inconsistencies in P. These derive largely from European

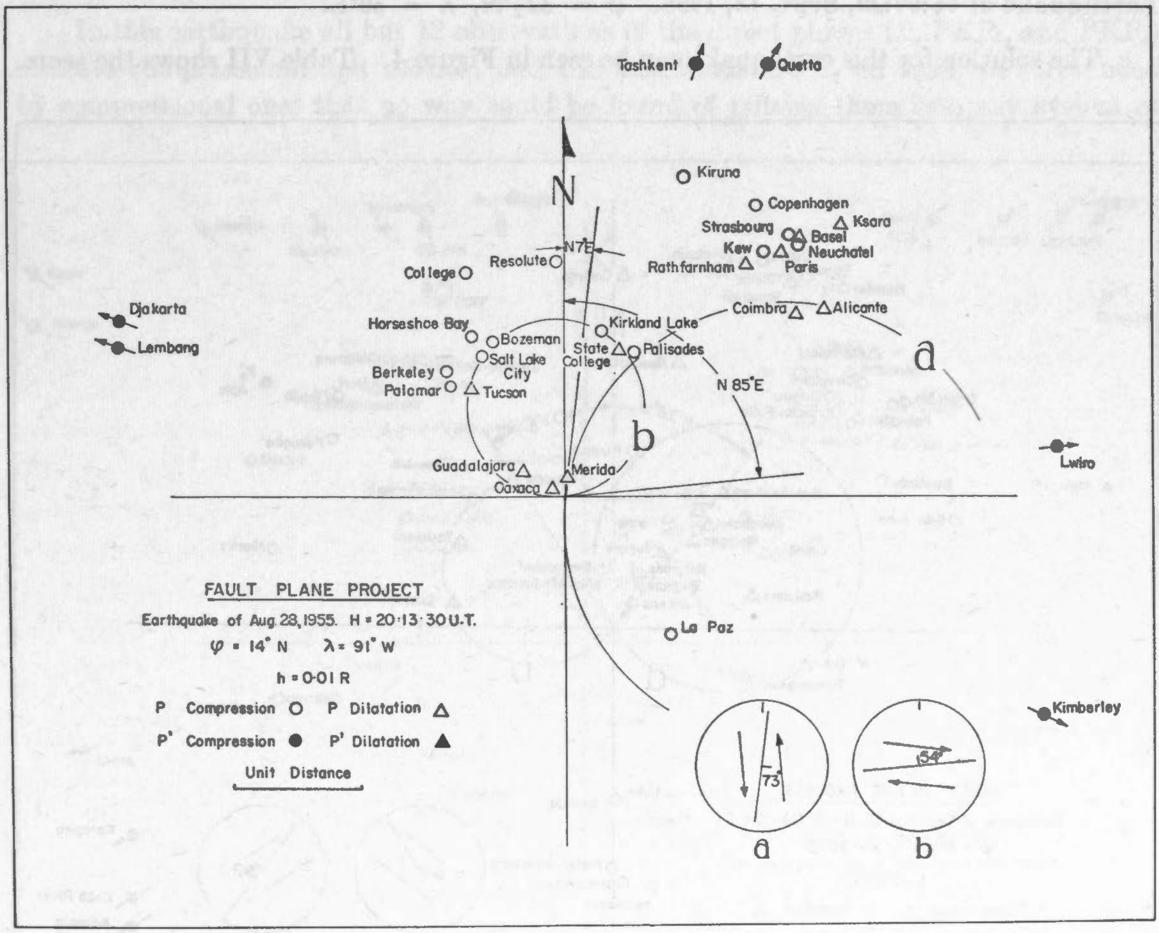

Figure 3

stations and reflect the doubts about the exact position of circle *a*. Rathfarnham, Paris, Basel and Ksara, for example report clear dilatations, but if circle *a* is increased in radius to include them, it makes inconsistent Kew and Palisades and a number of other stations not shown. The indicated solution is the best statistically; in any event the required variation would not be geologically large.

TABLE VI

	Direct Phases			Reflected Phases						
	P	P'_1	Total	PP	pP	pP'_1	PPP	pPP	PcP	Total
Total Number of Observations......	68	8	76	13	5	2	4	1	2	27
Number of Inconsistent Observations	18	0	18	4	3	2	1	1	2	13

Earthquake of 06:09:20, Sept. 12, 1955. $\varphi = 32\frac{1}{2}°N$, $\lambda = 30°E$.

The solution for this earthquake can be seen in Figure 4. Table VII shows the score.

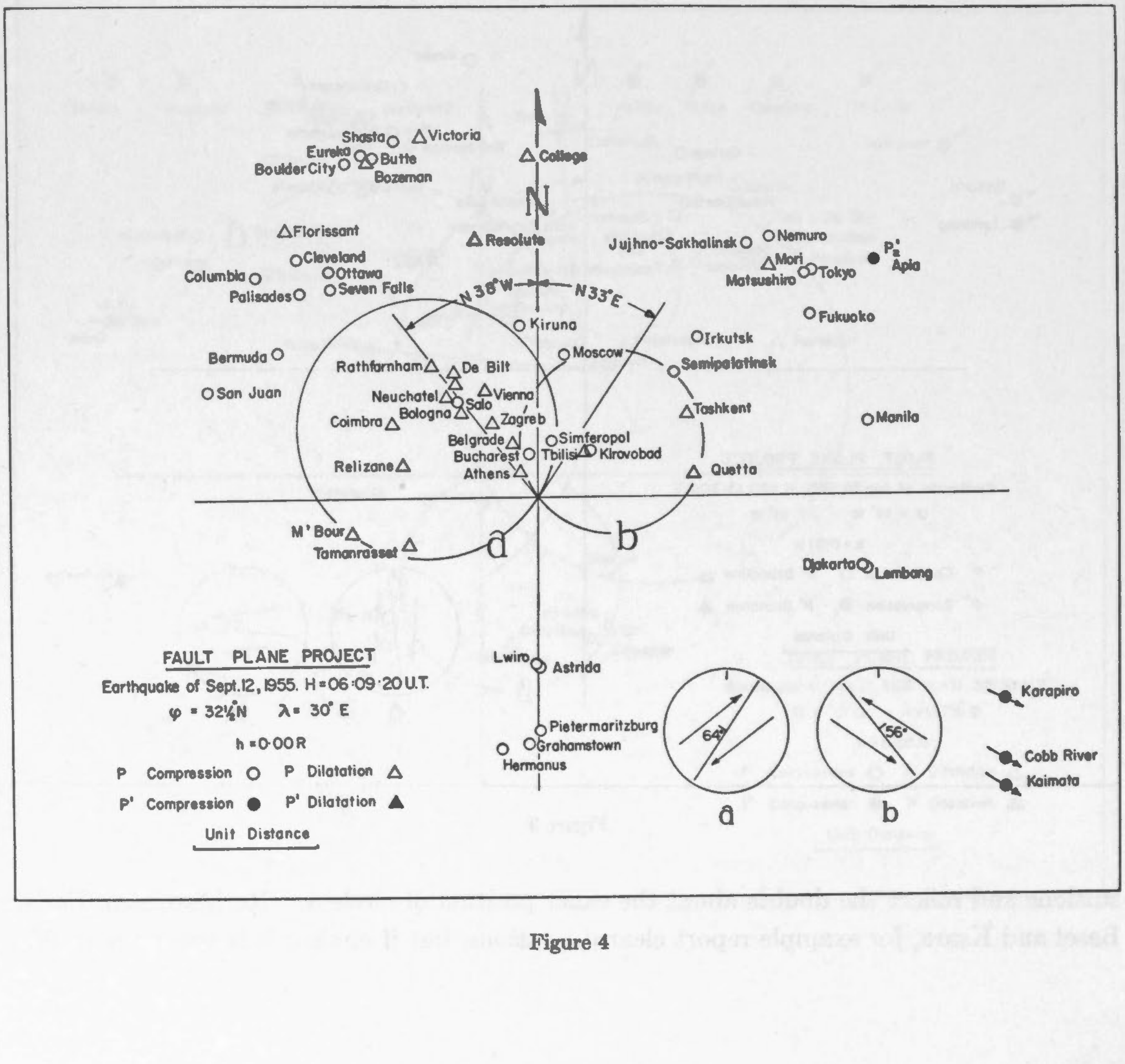

Figure 4

Nearly all the inconsistencies in P are contained well within areas of consistent data and thus cannot be brought into the solution. While the large number of inconsistencies is disturbing, it does not cast serious doubt on the solution.

TABLE VII

	Direct Phases				Reflected Phases						
	P	P'_1	P'_2	Total	PP	pP	pP'_1	PPP	pPP	PcP	Total
Total Number of Observations.......	90	4	1	95	4	3	1	2	1	2	13
Number of Inconsistent Observations.	19	1	0	20	2	3	1	0	0	1	7

Earthquake of 09:26:44, Oct. 13, 1955. $\varphi = 9\frac{1}{2}°S, \lambda = 161°E.$

In this earthquake all but 12 observations of the direct phases (P, PKP_1, and PKP_2) indicate compressional first motion, and the dilatations are in all cases so surrounded by compressional ones that no way could be found of putting them into any system of

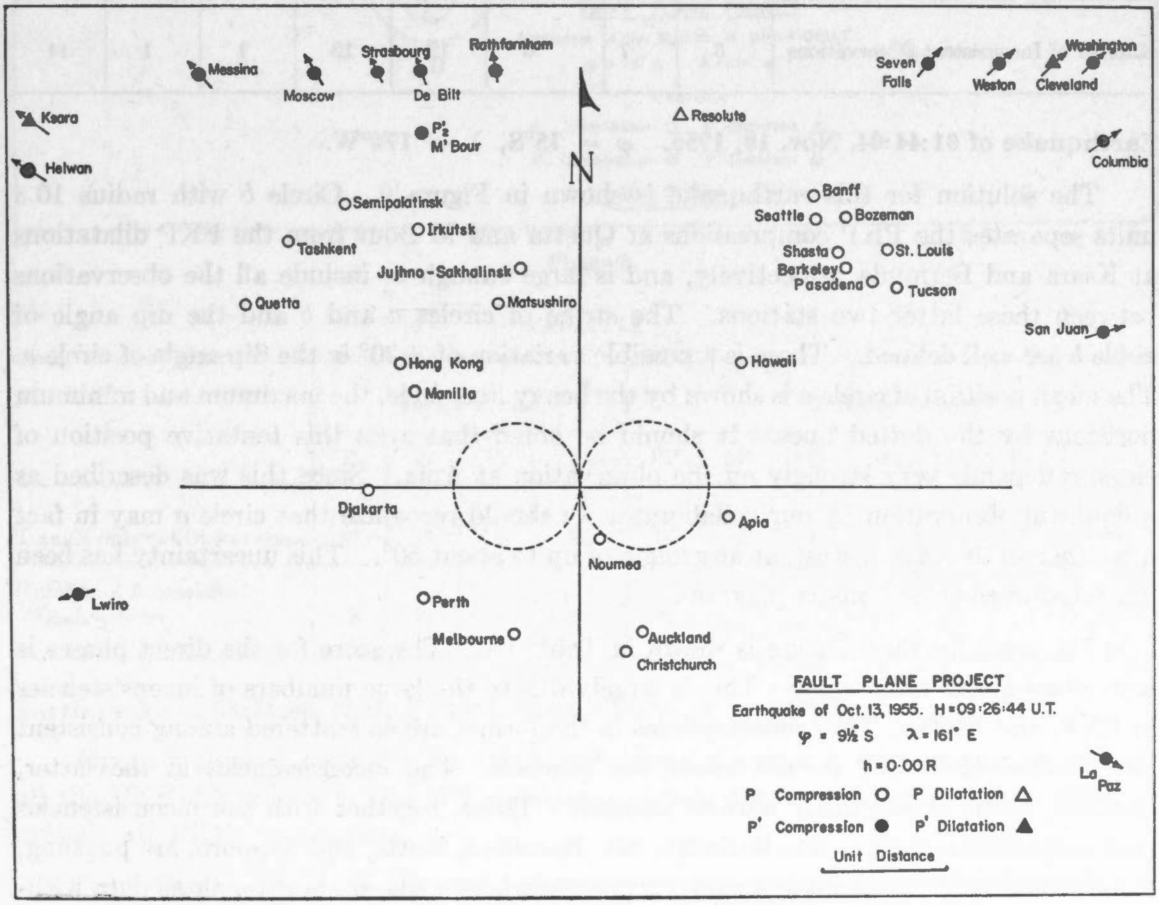

Figure 5

circles. It was necessary to conclude that all the observations should have been compressional, and that the solution would consist of a pair of dilatational circles drawn in the area, close to the epicentre, which was free of observation. This could have been done in an infinity of ways. The diagram (Figure 5) shows one possible set, a pair of planes striking N and each dipping at 45°, but a circle representing a plane dipping as much as 63° could have been drawn in the free area.

In drawing a second circle however we would have been limited to circles having approximately the same strike direction; from this we may conclude that faulting is probably thrust, on a fault having an unknown strike and dip.

We regard this as a solution in the sense that the observations have been satisfactorily accounted for. The score for the solution is given in Table VIII.

TABLE VIII

	Direct Phases				Reflected Phases			
	P	P'_1	P'_2	Total	PP	pP	PPP	Total
Total Number of Observations.......	63	37	3	103	19	3	2	24
Number of Inconsistent Observations.	5	7	0	12	12	1	1	14

Earthquake of 01:44:04, Nov. 10, 1955. $\varphi = 15°S, \lambda = 174°W$.

The solution for this earthquake is shown in Figure 6. Circle *b* with radius 10.3 units separates the PKP compressions at Quetta and M'Bour from the PKP dilatations at Ksara and Bermuda respectively, and is large enough to include all the observations between these latter two stations. The strike of circles *a* and *b* and the dip angle of circle *b* are well defined. There is a possible variation of ±20° in the dip angle of circle *a*. The mean position of circle *a* is shown by the heavy line circle, the maximum and minimum positions by the dotted lines. It should be noted that even this tentative position of circle *a* depends very strongly on the observation at Apia. Since this was described as a doubtful observation by our collaborator we should recognize that circle *a* may in fact dip either to the east or west, at any angle of up to about 50°. This uncertainty has been indicated in the single insert diagram.

The score for the solution is shown in Table IX. The score for the direct phases is somewhat poorer than usual. This is largely due to the large numbers of inconsistencies in PKP_1 and PKP_2. The inconsistencies in the former are so scattered among consistent observations that they do not affect the solution. The inconsistencies in the latter, however, occur in one fairly narrow azimuth. These, together with the inconsistencies from dependable stations like Berkeley, Mt. Hamilton, Butte, and Sapporo, are puzzling, yet it is impossible to find a solution which will satisfactorily account for these data without producing a much poorer score in the P observation.

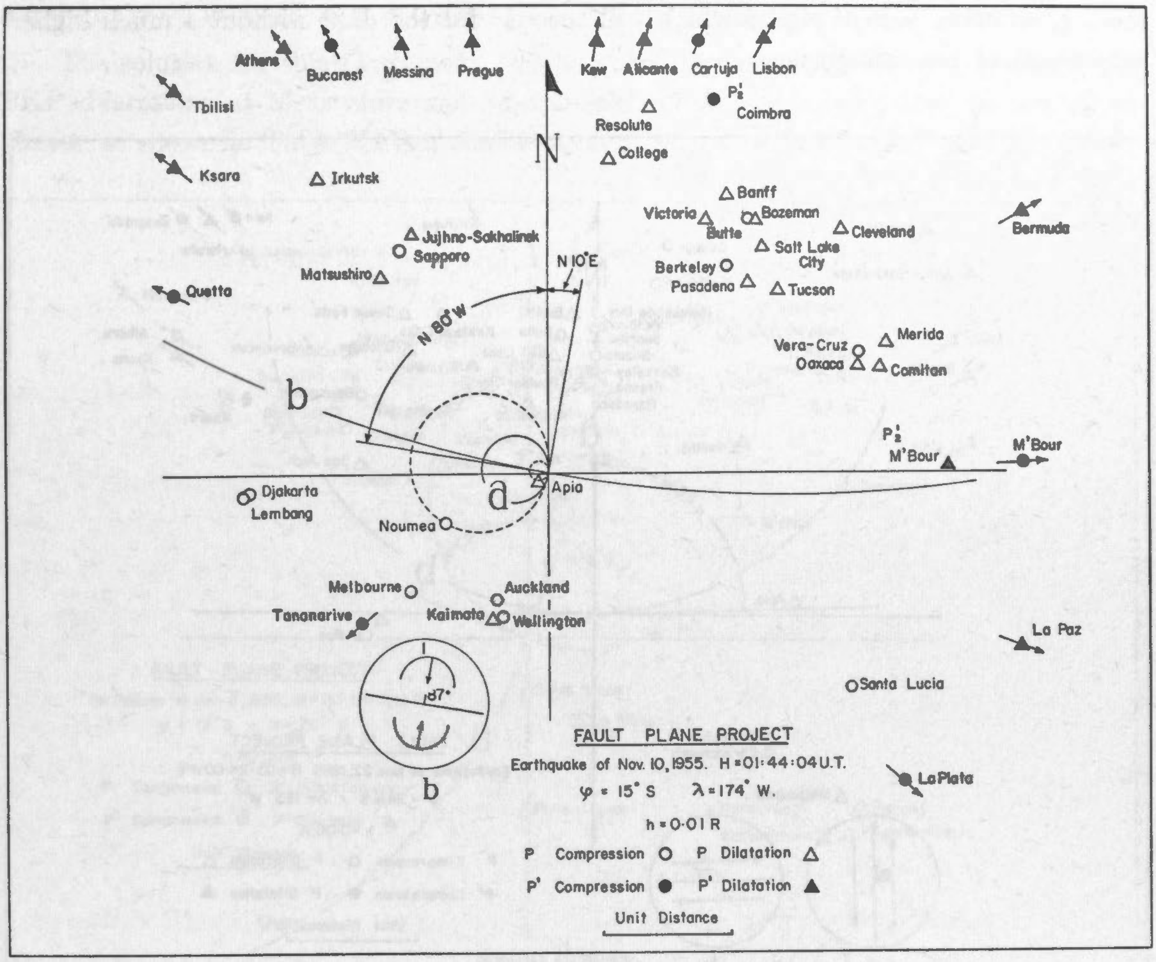

Figure 6

TABLE IX

	Direct Phases				Reflected Phases						
	P	P'_1	P'_2	Total	PP	pP	pP'_1	pP'_2	pPP	PcP	Total
Total Number of Observations	42	42	5	89	16	2	8	1	1	1	29
Number of Inconsistent Observations............	8	10	4	22	11	1	2	0	0	1	15

Earthquake of 03:24:00, Nov. 22, 1955. $\varphi = 24\frac{1}{2}$°S, $\lambda = 123$°W.

Figure 7 gives the solution for this earthquake. Circle *a* is large enough to include all the PKP dilatations in the NW quadrant. Circle *b* has sufficiently small radius to exclude all PKP observations.

From Table X it can be seen that the number of inconsistencies in the direct phases is rather high. Nevertheless the solution is submitted with some confidence because there is no other pair of circles which will account for the data without a much higher percentage of inconsistencies.

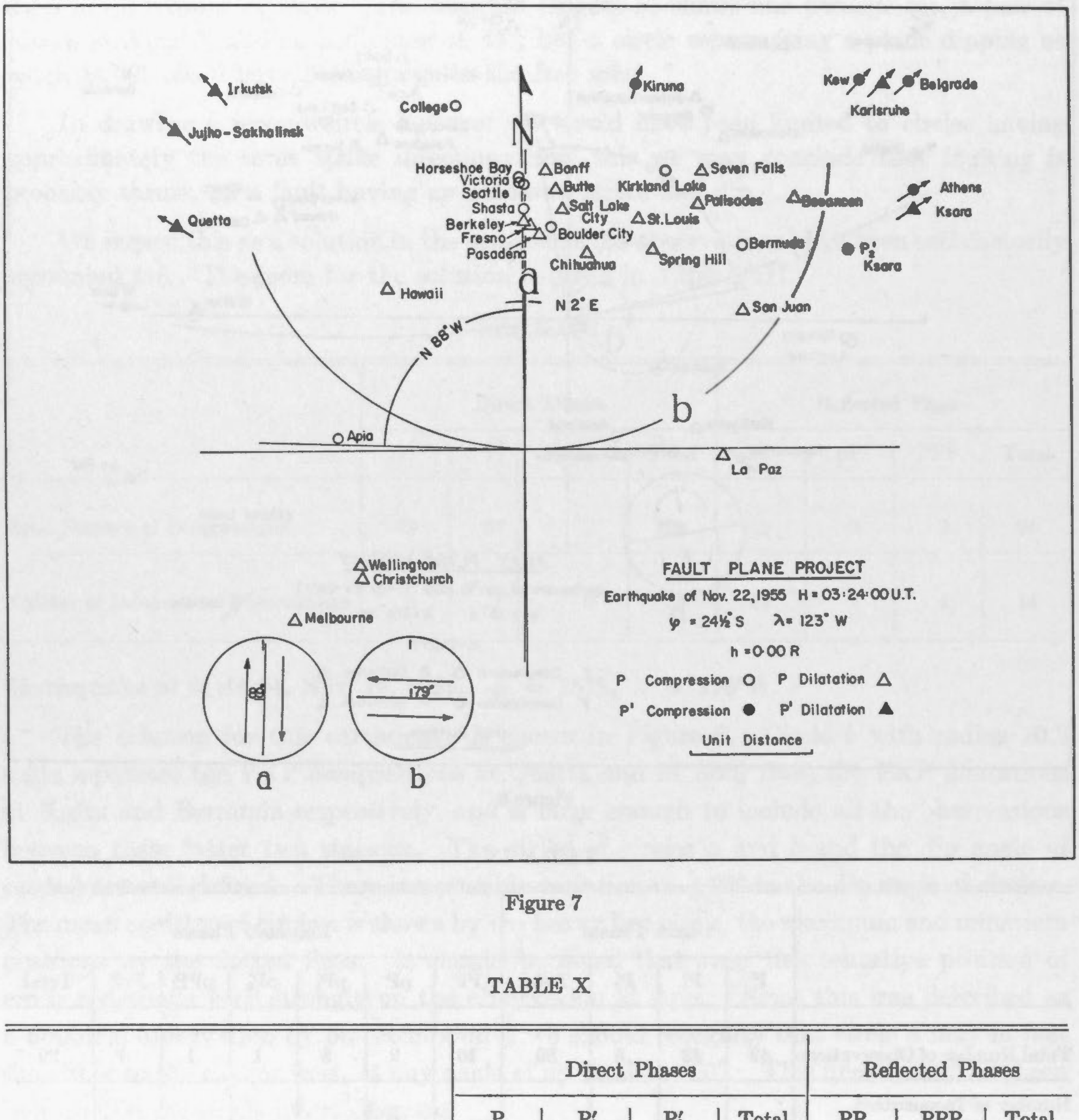

Figure 7

TABLE X

	Direct Phases				Reflected Phases		
	P	P'_1	P'_2	Total	PP	PPP	Total
Total Number of Observations...............	41	13	1	55	3	1	4
Number of Inconsistent Observations........	10	4	0	14	1	0	1

This is the first earthquake in this geographic area—the Eastern Tuamota Archipelago—for which a fault-plane solution has been obtained.

Earthquake of 20:54:13, Jan. 8, 1956. $\varphi = 19°S$, $\lambda = 70°W$.

The solution for this earthquake will be found in Figure 8. Circle *a* excludes the PKP dilatations at Matsushiro and Jujhno-Sakhalinsk. The poor score in the direct phases, as shown in Table XI is a combination of poor scores in both P and P_1'. Since

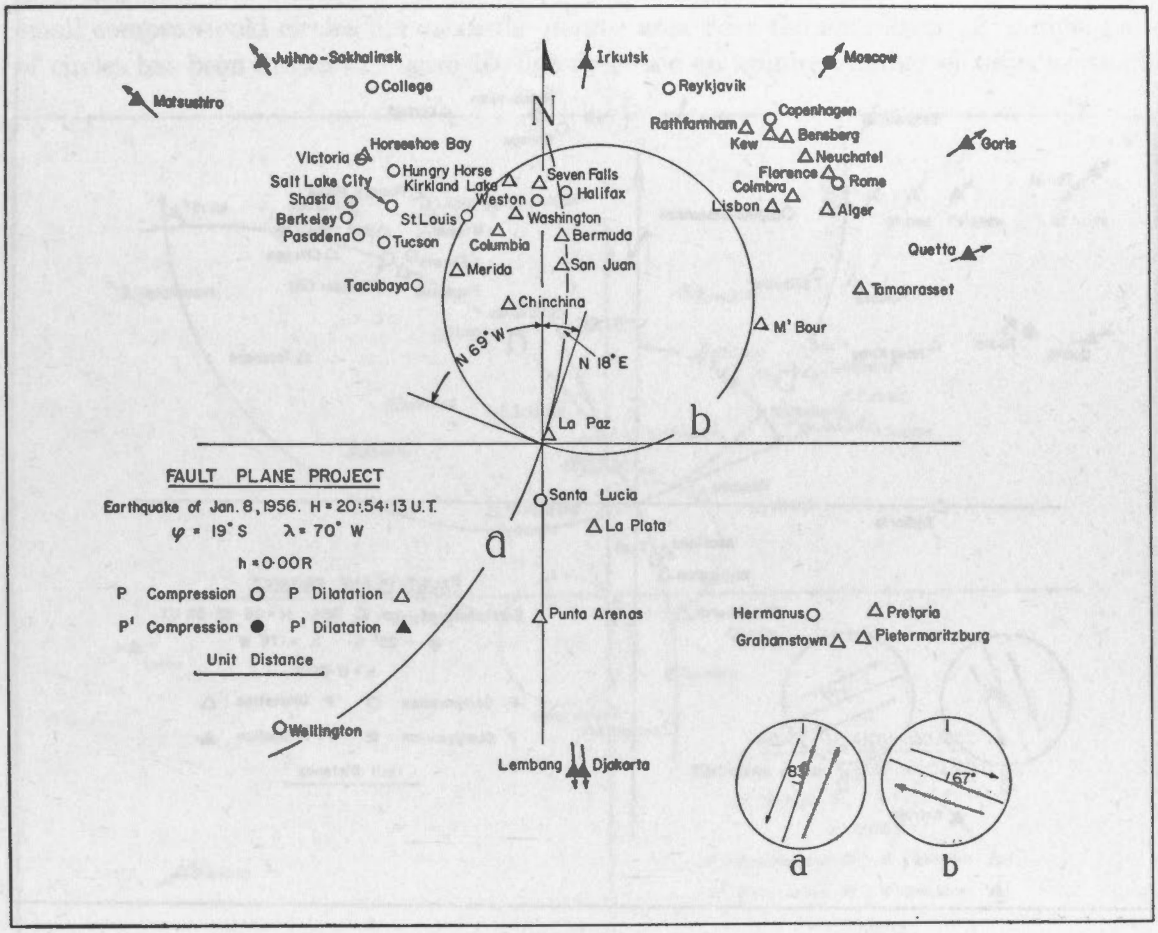

Figure 8

the corresponding inconsistencies are distributed at randon among consistent observations, they do not cast any doubt on the final solution.

TABLE XI

	Direct Phases			Reflected Phases				
	P	P_1'	Total	PP	pP	PPP	pPP	Total
Total Number of Observations......	78	11	89	17	3	3	1	24
Number of Inconsistent Observations.	17	4	21	6	2	0	0	8

Earthquake of 08:52:36, Jan. 10, 1956. $\varphi = 25°S$, $\lambda = 176°W$.

As shown in Table XII there are fewer observations than usual for this earthquake but, except for the large number of inconsistencies in P_2' the percentage of inconsistencies is satisfactory. Circle *a* (Figure 9) has remarkable success in separating Tuai from the rest of the New Zealand stations, and Pasadena from the rest of the California ones, and is very closely defined. Circle *b* is not so closely defined, but has been drawn in the mean position to separate Fukuoko and Shizuoko.

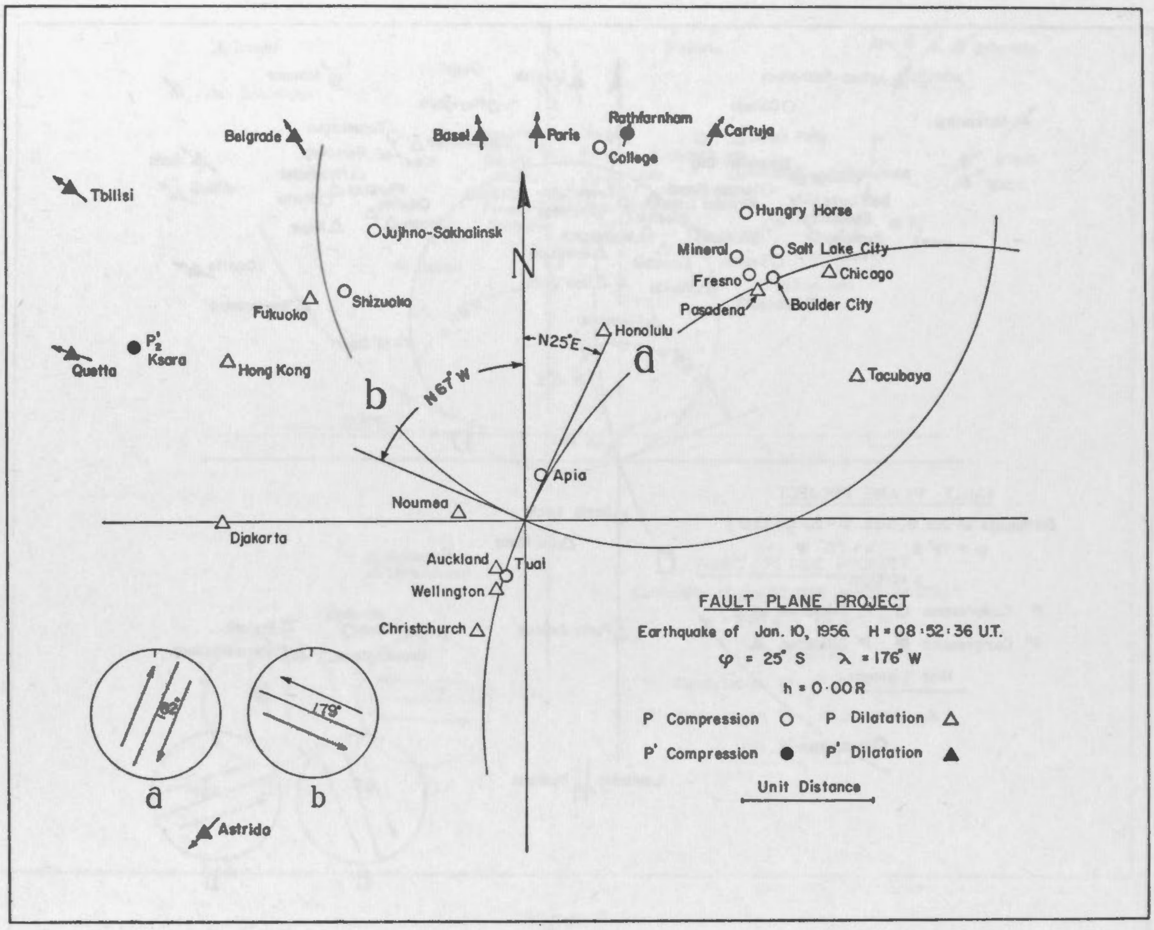

Figure 9

TABLE XII

	Direct Phases				Reflected Phases	
	P	P_1'	P_2'	Total	PP	Total
Total Number of Observations	30	17	4	51	11	11
Number of Inconsistent Observations	3	3	4	10	4	4

Earthquake of 09:17:11, Jan. 31, 1956. $\varphi = 4°S$, $\lambda = 152°E$.

This earthquake like that of Oct. 13, 1955, discussed earlier, and that of Feb. 1, 1956 to follow, is so located that the solution circles cannot be defined, even though the observations are well accounted for. In the present case all but 6 of 66 observations of P and PKP are dilatational, and the only possible solution is provided by a pair of small compressional circles drawn in the empty area near the epicentre. A sample pair of circles has been drawn in Figure 10, but there are an infinite number of ways in which

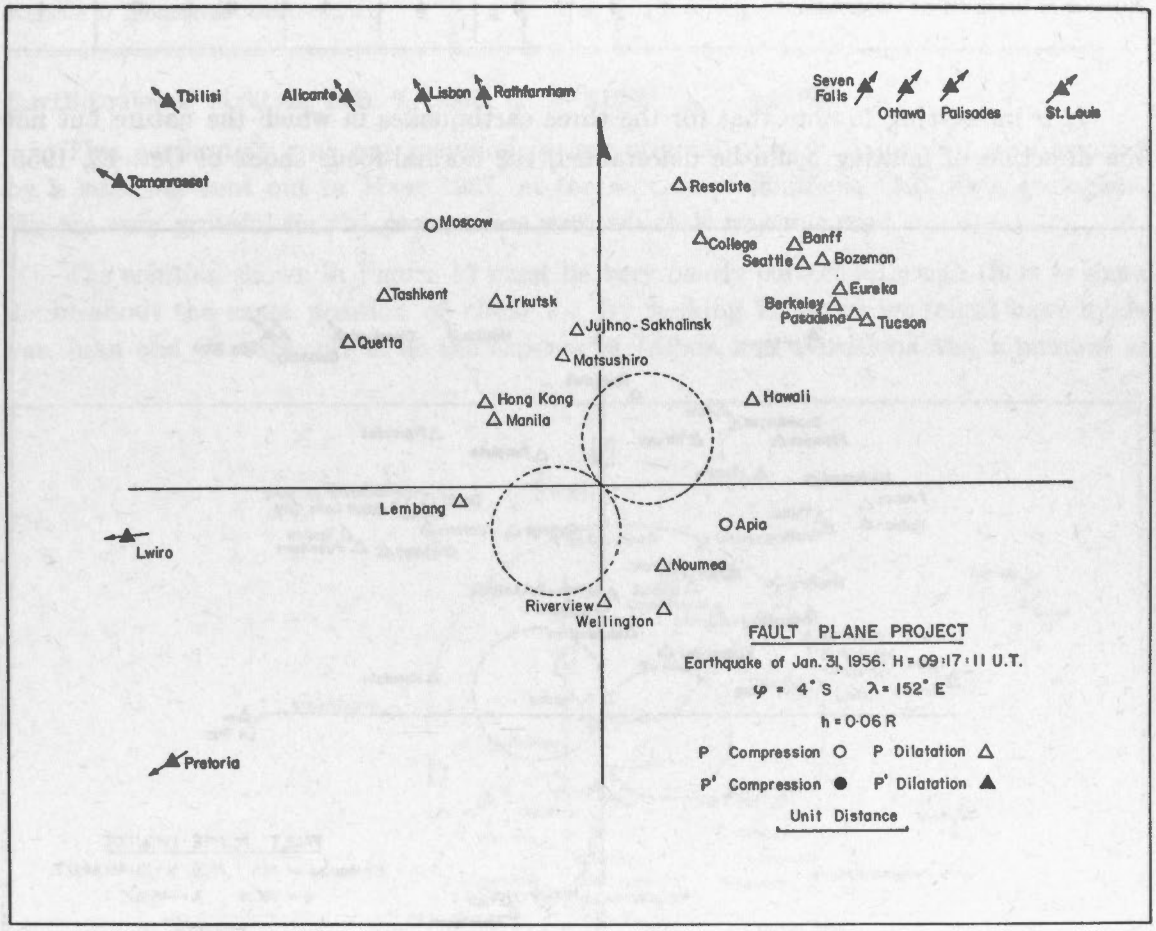

Figure 10

this could have been done. We may conclude that faulting is normal on a fault of indeterminate strike and dip. The circles could easily be drawn in such a way as to make Apia consistent; this has not been done because the observation was described as uncertain. The score is given in Table XIII.

Earthquake of 13:41:44, Feb. 1, 1956. $\varphi = 19°N$, $\lambda = 145\frac{1}{2}°E$.

Again we present an earthquake (*see* Figure 11) in which the solution cannot be defined because of the scarcity of stations close to the epicentre, but in which it is possible to conclude that the faulting is normal along a plane of indeterminate strike and dip. The score given in Table XIV is very good in the direct phases.

TABLE XIII

	Direct Phases			Reflected Phases			
	P	P_1'	Total	PP	pP	PPP	Total
Total Number of Observations..............	40	26	66	6	3	1	10
Number of Inconsistent Observations.........	1	3	4	4	0	0	4

It is interesting to note that for the three earthquakes in which the nature but not the direction of faulting could be determined, the normal-focus shock of Oct. 13, 1955,

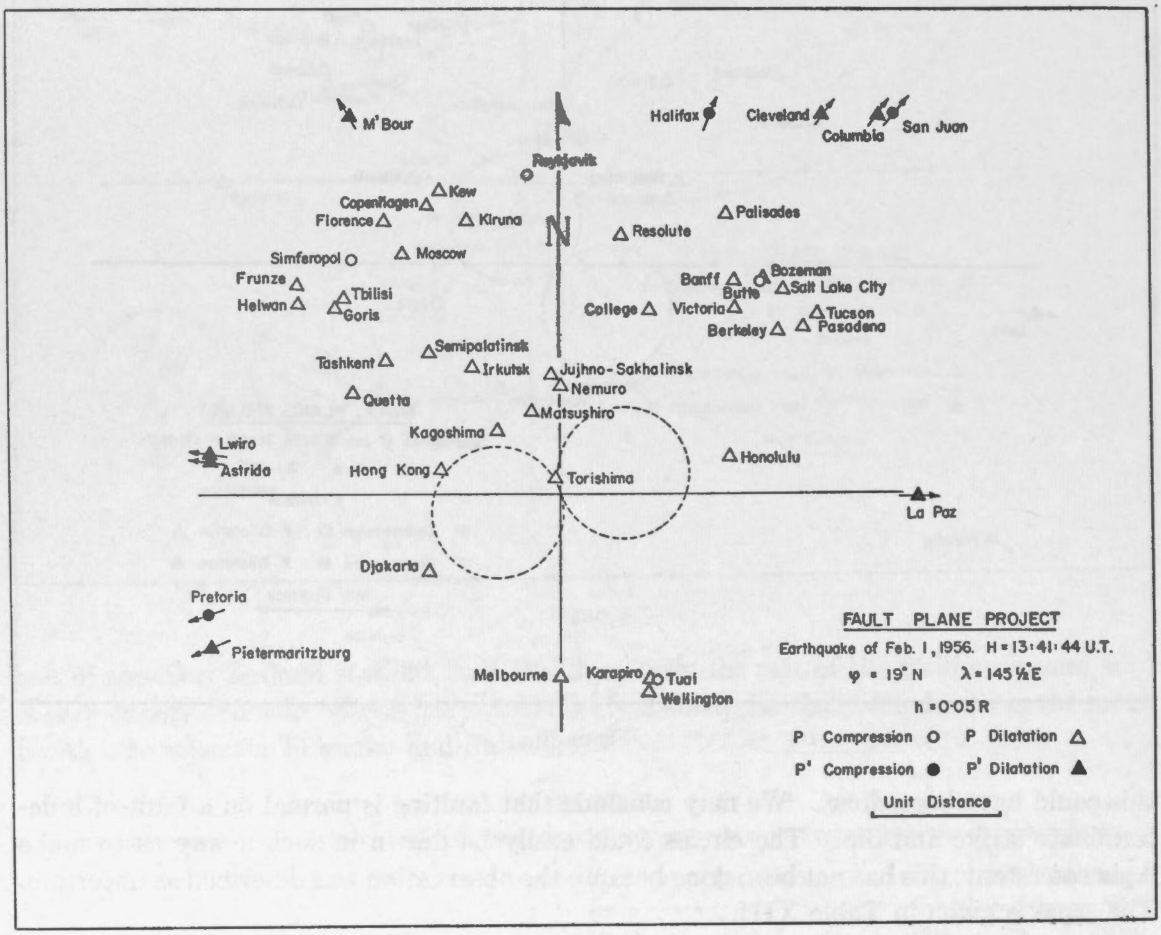

Figure 11

showed thrust faulting, while the deep-focus earthquakes of Jan. 31, 1956 and Feb. 1, 1956, showed tension faulting. This is what would have been expected on the contraction hypothesis.

TABLE XIV

	Direct Phases			Reflected Phases						
	P	P$'_1$	Total	PP	pP	pP$'_1$	PPP	pPP	PcP	Total
Total Number of Observations......	117	14	131	20	12	1	5	1	1	40
Number of Inconsistent Observations	9	6	15	12	7	1	5	1	1	27

Earthquake of 14:32:40, Feb. 9, 1956. $\varphi = 31\frac{1}{2}°N$, $\lambda = 116°W$.

This earthquake was not included in our original questionnaire, but was covered by a later one sent out in May, 1957, at the request of Southern California geologists. We are very grateful for the promptness with which it was returned.

The solution shown in Figure 12 must be very nearly correct although there is some doubt about the exact position of circle *b*. By making it larger we might have made San Juan and Cartuja correct at the expense of Lisbon and Barcelona and a number of

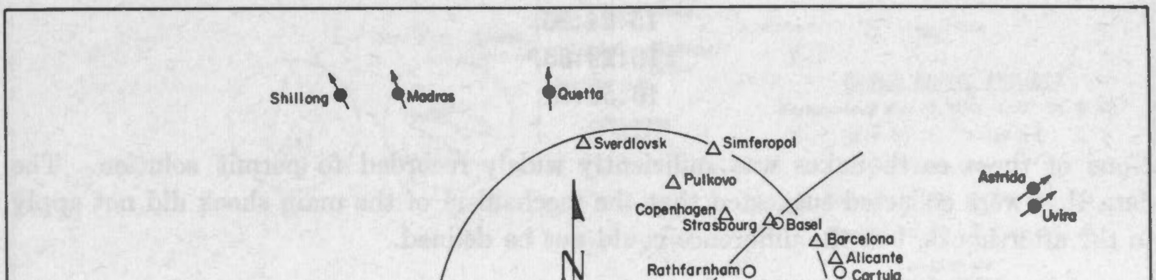

Figure 12

other stations not given in the diagram. The adopted position gives the best score, but the uncertainty is reflected in the high percentage of inconsistencies in P as shown in Table XV.

TABLE XV

	Direct Phases			Reflected Phases			
	P	P_1'	Total	PP	PPP	PcP	Total
Total Number of Observations..............	82	9	91	4	2	1	7
Number of Inconsistent Observations.........	15	2	17	2	0	1	3

No description of the observed faulting has yet been published, but we are advised by Dr. Clarence R. Allen* that "tentatively, plane *b* corresponds very nicely with the observed break and with the line of aftershock epicentres".

The same questionnaire sought information on principal aftershocks, with the following H times:

15:24:26,
16:29:53,
16:59:54.

None of these earthquakes was sufficiently widely recorded to permit solution. The data that were collected suggested that the mechanism of the main shock did not apply to the aftershocks, but the difference could not be defined.

Earthquake of 07:34:16, Feb. 18, 1956. $\varphi = 30°N, \lambda = 137\frac{1}{2}°E$.

The solution for this earthquake is given in Figure 13. The only serious inconsistencies are in the upper NE quadrant where Weston, Shawinigan Falls, and Cleveland dilatations are found among Ottawa and Kirkland Lake compressions. To bring the former into the solution would have meant shifting circle *b* clockwise without significantly changing its radius. However this would have sacrificed compressions at a number of European and Japanese stations, not all shown on the diagram. Statistically, the solution

TABLE XVI

	Direct Phases			Reflected Phases							
	P	P_1'	Total	PP	pP	pP_1'	PPP	pPP	pPPP	PcP	Total
Total Number of Observations....	105	5	110	19	23	1	5	2	1	2	53
Number of Inconsistent Observations.................	19	2	21	10	16	1	3	1	0	1	32

* Personal communication.

as given is much better and the score for the direct phases (*see* Table XVI) has about the usual value. Inconsistencies other than those mentioned are scattered throughout the diagram apparently at random and reflect no doubt on the solution.

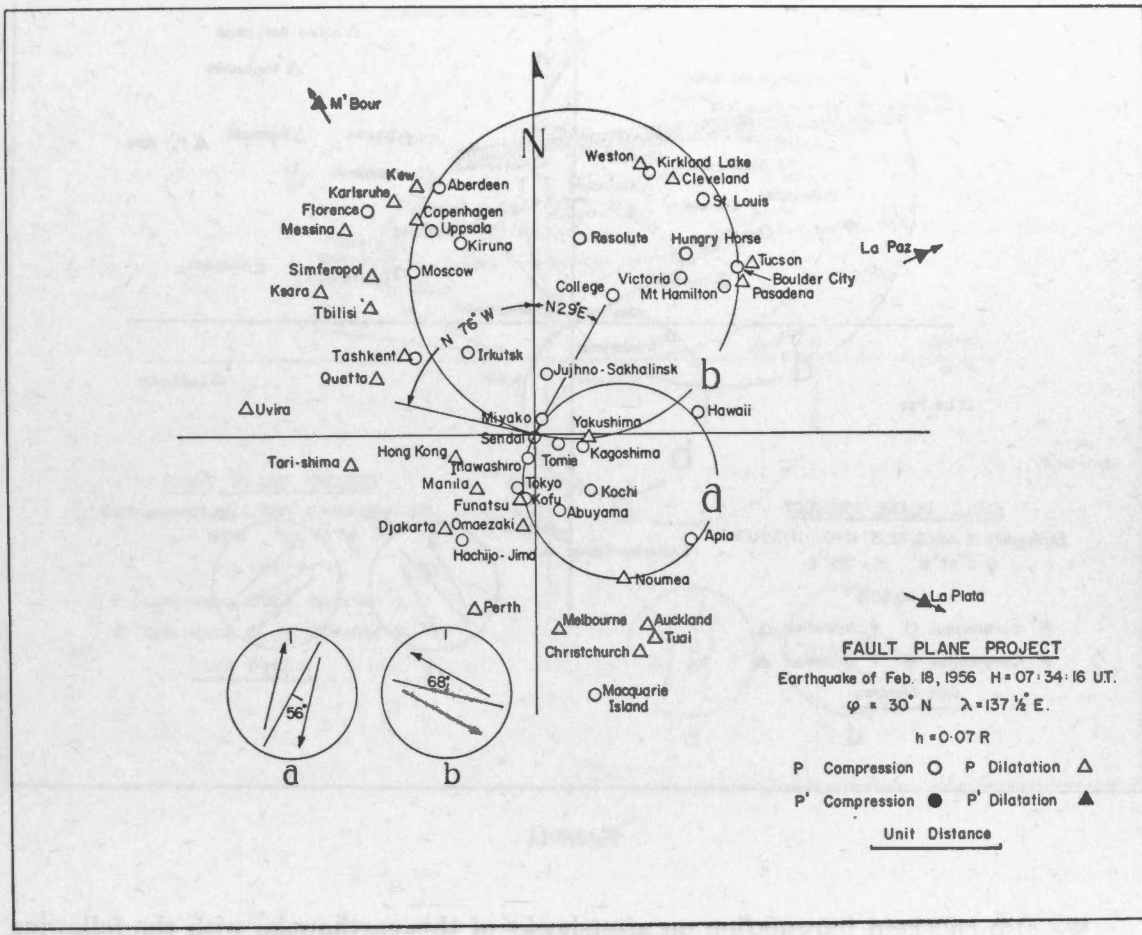

Figure 13

Earthquake of 03:11:39, July 9, 1956. $\varphi = 37°N$, $\lambda = 26°E$.

Our solution for this earthquake is shown in Figure 14 and the score is given in Table XVII. It will be seen that the number of inconsistencies is higher than usual. Many of these inconsistent observations arise in a narrow band, shown shaded in the diagram, which suggests the possibility that some other mechanism may be operating. The solution should therefore be regarded with some reservation.

TABLE XVII

	Direct Phases				Reflected Phases				
	P	P'_1	P'_2	Total	PP	pP	PPP	PcP	Total
Total Number of Observations	96	1	1	98	9	1	2	2	14
Number of Inconsistent Observations	24	1	0	25	7	1	0	2	10

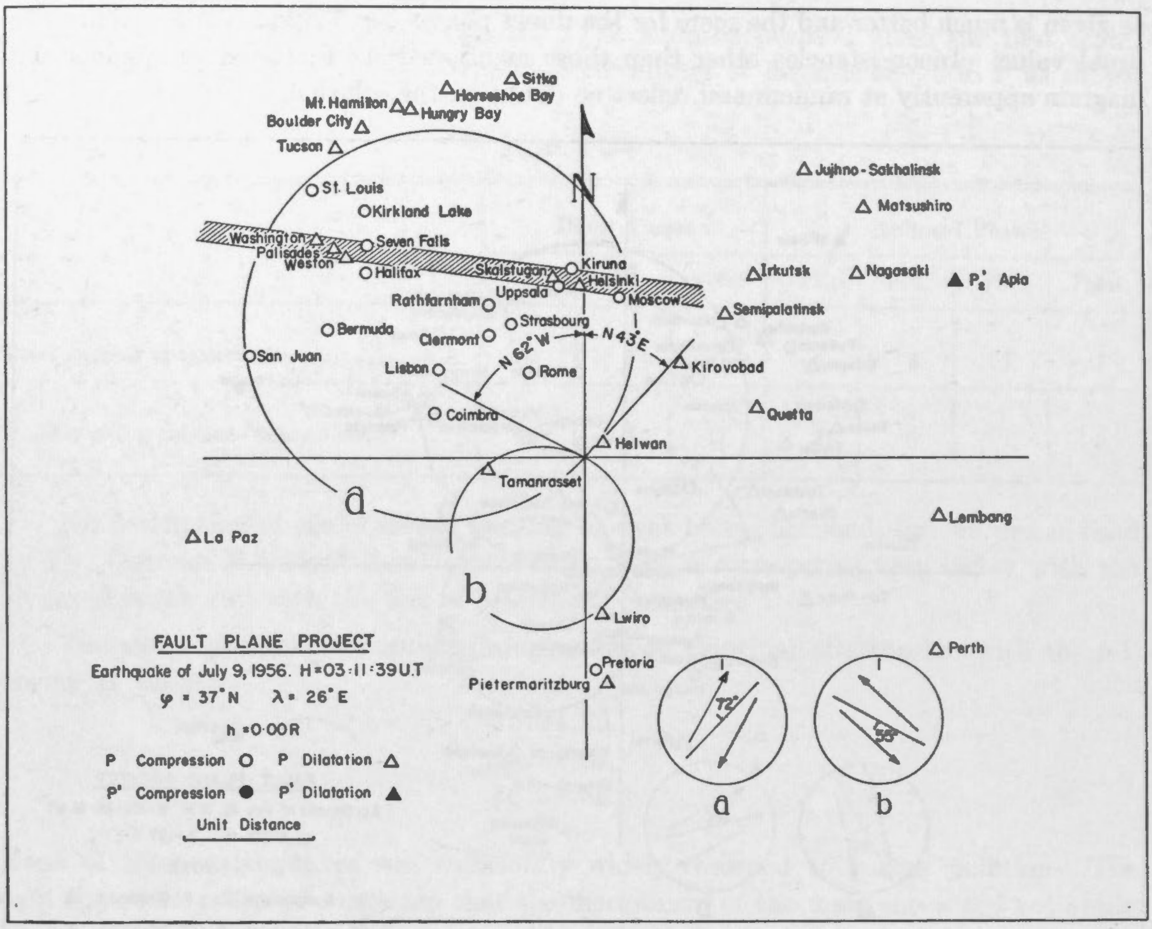

Figure 14

We also collected information on aftershocks of this earthquake with the following H times:

July 9, 1956, 03:24:05,
06:19:07,
06:22:49,
July 10, 1956, 03:01:27.

There were not sufficient data on any of these aftershocks to permit solutions.

Earthquake of 09:56:13, July 9, 1956. $\varphi = 20°N, \lambda = 73°W.$

The solution for this earthquake is shown in Figure 15, and the score is given in Table XVIII. The solution is straightforward except that both circles *a* and *b* have been drawn in mean positions from which they might deviate by about ±5°.

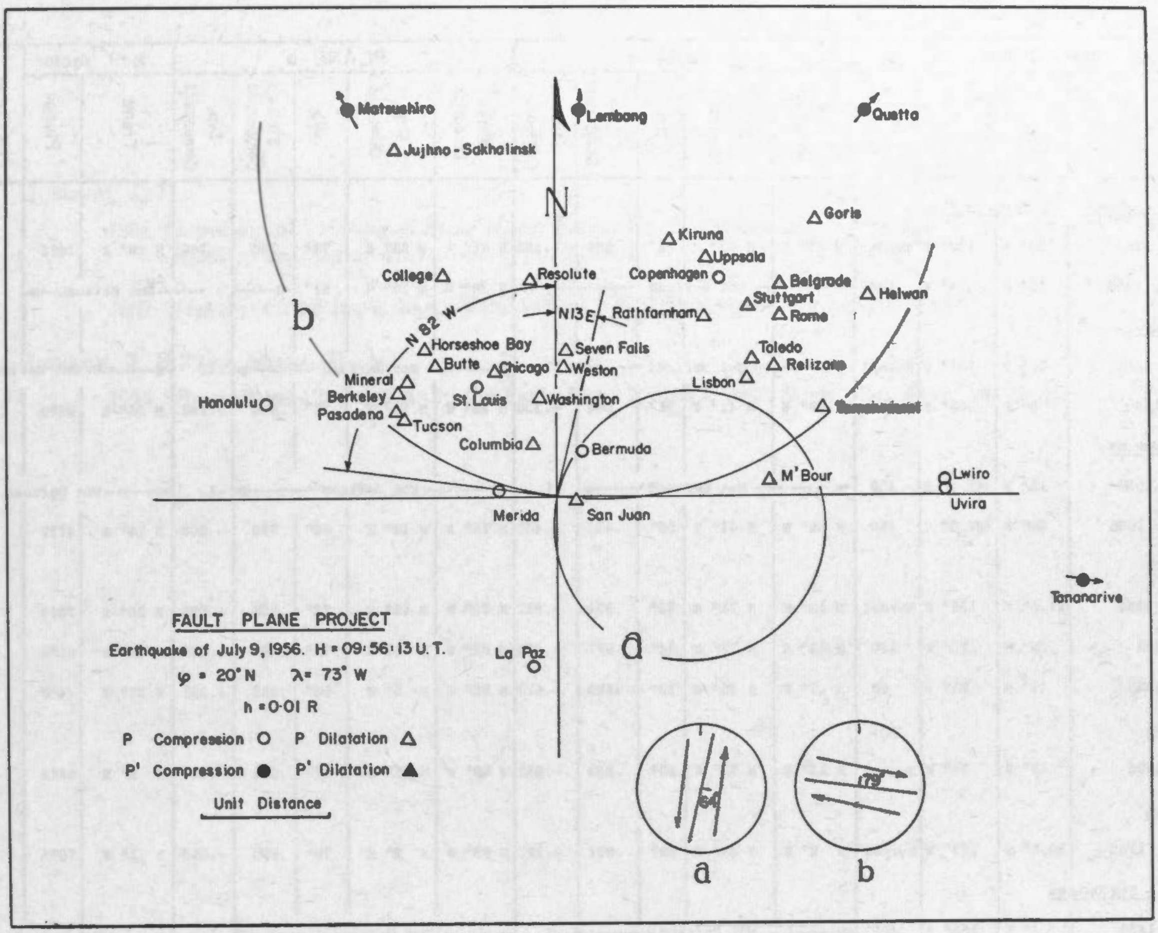

Figure 15

TABLE XVIII

	Direct Phases			Reflected Phases					
	P	P_1	Total	PP	pP	PPP	pPP	PcP	Total
Total Number of Observations...........	89	4	93	15	3	1	1	2	22
Number of Inconsistent Observations.......	14	0	14	7	1	1	1	1	11

SUMMARY

The solutions have been summarized in Table XIX, which is similar in form to the tables used in a recent review paper (Hodgson, 1957). Until more solutions have accumulated in this second series of solutions, no further discussion of the results is justified.

Table XIX

EARTHQUAKE				PLANE a					PLANE b					Null Vector		DEXTRAL Solution	SINISTRAL Solution
DATE	φ	λ	Focal Depth-km.	Strike Direction	Dip Direction	Dip	Strike Component	Dip Component	Strike Direction	Dip Direction	Dip	Strike Component	Dip Component	Trend	Plunge		
<u>New Zealand - Kermadecs - Tonga - Fiji</u>																	
January 10, 1956	25° S	176° W	Normal	N 25° E	S 65° E	82°	.981	-.193	N 67° W	N 23° E	79°	.990	-.142	N 60° E	76.°4	a	b
November 10, 1955	15° S	174° W	100	← Not Defined →					N 80° W	N 10° E	87°	←	+	Not Defined →		a	b
<u>Solomon Islands</u>																	
October 13, 1955	9.5 S	161° E	Normal	← Not Defined →				+1.	← Not Defined →				+1.	← Not Defined →			
August 16, 1955	6° S	155° E	200	N 49° E	N 41° W	81°	.944	+.330	N 38° W	N 52° E	71°	.986	+.166	N 26° E	68.°9	a	b
<u>Marianas - Bonins</u>																	
February 1, 1956	19° N	145.5° E	350	← Not Defined →				-1.	← Not Defined →				-1.	← Not Defined →			
February 18, 1956	30° N	137.5° E	450	N 29° E	S 61° E	56°	.892	-.452	N 76° W	N 14° E	68°	.798	-.603	N 78° E	47.°7	a	b
<u>North America</u>																	
February 9, 1956	31.5° N	116° W	Normal	N 19° E	S 71° E	85°	.951	+.311	N 72° W	N 18° E	72°	.996	+.092	N 35° E	70.°9	b	a
July 9 B, 1956	20° N	73° W	100	N 13° E	S 77° E	64°	.977	+.213	N 82° W	N 8° E	79°	.894	+.447	N 77° E	61.°6	b	a
August 28, 1955	14° N	91° W	60	N 7° E	S 83° E	73°	.789	+.615	N 85° E	N 5° W	54°	.932	+.361	N 27° E	48.°6	b	a
<u>South America</u>																	
January 8, 1956	19° S	70° W	Normal	N 18° E	N 72° W	83°	.919	-.393	N 69° W	N 21° E	67°	.991	-.132	N 2° E	65.°8	b	a
<u>South Pacific</u>																	
November 22, 1955	24.5° S	123° W	Normal	N 2° E	N 88° W	89°	.981	+.197	N 88° W	N 2° E	79°	.999	+.018	N 1° W	78.°5	a	b
<u>New Britain - New Guinea</u>																	
January 31, 1956	4° S	152° E	400	← Not Defined →				-1.	← Not Defined →				-1.	← Not Defined →			
August 21, 1955	3° S	137.5° E	Normal	N 74° E	S 16° E	60°	.934	+.357	N 26° W	N 64° E	72°	.851	+.526	S 53° E	54.°0	b	a
<u>Mediterranean</u>																	
September 12, 1955	32.5° N	30° E	Normal	N 33° E	N 57° W	64°	.783	+.623	N 38° W	N 52° E	56°	.849	+.529	N 4° E	44.°2	a	b
July 9 A, 1956	37° N	26° E	Normal	N 43° E	N 47° W	72°	.798	-.603	N 62° W	S 28° W	55°	.926	-.377	S 65° W	48.°1	a	b

It was mentioned in the introduction that the reflected phases would not be used in the solutions, but that solutions based on the direct phases alone would be used to test the reliability of the reflected phases. The results of this analysis have been given with each solution, but they are summarized in Table XX. It is clear once again that none of the reflected phases is reliable.

TABLE XX

Phase	PP	pP	pP′₁	pP′₂	pPP	PPP	pPPP	PcP
Number of Observations............	201	66	21	1	14	33	1	16
Number of Inconsistencies...........	103	39	12	0	8	13	0	12
Percentage of Inconsistencies........	51.2	59.1	57.1	0.0	57.1	39.4	0.0	75.0

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