CANADA
DEPARTMENT OF MINES AND TECHNICAL SURVEYS
DOMINION OBSERVATORIES

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

VOLUME XVIII No. 9

DIRECTION OF FAULTING IN SOME OF THE LARGER EARTHQUAKES OF THE SOUTHWEST PACIFIC, 1950-1954

BY

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QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1956

600—1956

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ABSTRACT

The direction of faulting is determined for 23 earthquakes occurring in the southwest Pacific during the years 1950-1954. These solutions are combined with five published earlier by Webb and two published earlier by Hodgson and Storey, to permit a study of the failure pattern in the area.

It is concluded that faulting in the southwest Pacific is principally strike-slip, on steeply dipping planes. The strike direction of the faults is not consistent nor does it show any systematic variation with latitude, depth of focus or position on the associated arcuate feature.

The solutions obtained are ambiguous in that two orthogonal planes are determined, and it is not known which of these planes represents the fault. Whichever plane represents the fault, the line of intersection of the two planes is a line uniquely determined by the solution. The line, which is here called the "null vector" appears to have great significance. For the New Hebrides earthquakes the null vectors lie closely parallel to a vertical plane striking N 22° W, that is, to a vertical plane having the direction of the associated feature. Similarly the null vectors of earthquakes associated with the Tonga-Kermadec-New Zealand feature lie nearly parallel to a vertical plane striking N 24° E, the mean direction of that feature.

The physical significance of these correlations has not yet been determined, but it seems clear that the association cannot be accidental. Under the circumstances the techniques of the fault-plane project must receive a considerable degree of confirmation.

INTRODUCTION

During the past several years this Observatory has produced a series of papers[1,2,3,4] dealing with the direction of faulting in earthquakes. The present paper will present solutions for an additional 23 earthquakes, all from the southwest Pacific. Data for these solutions derive from two sets of questionnaires, one circulated in November 1951, the other in March, 1954.

An explanation is due to our collaborators for the delay in bringing the results of the 1951 questionnaire to publication. Nine solutions were obtained as a result of this questionnaire, and these solutions were prepared for publication in summary form, without the solution diagrams and without a tabulation of the data. This was done with the thought that the method had by now been established. However, so many of the solutions represent transcurrent faulting, contrary to existing tectonophysical theories, that it was suggested that the complete solutions should be published so that critics of the method might have an opportunity of examining them. The paper which had been prepared was therefore not published. In the meantime the second questionnaire had been circulated, and it was decided to postpone publication of the first group of analyses until the second had been completed. The results of the first group, consisting of nine 1950 earthquakes, have

[1] J. H. Hodgson and W. G. Milne, "Direction of Faulting in Certain Earthquakes of the North Pacific", *Bull. Seism. Soc. Am.*, 41, 221-242, 1951.
[2] J. H. Hodgson and P. C. Bremner, "Direction of Faulting in the Ancash, Peru, Earthquake of November 10, 1946, from Teleseismic Evidence", *Bull. Seism. Soc. Am.*, 43, 121-125, 1953.
[3] J. H. Hodgson and R. S. Storey, "Direction of Faulting in some of the Larger Earthquakes of 1949", *Bull. Seism. Soc. Am.*, 44, 57-83, 1954.
[4] J. H. Hodgson, "Fault Plane Solution for the Tango, Japan, Earthquake of March 7, 1927", *Bull. Seism. Soc. Am.*, 45, 37-41, 1955.

already been included in a summary paper[5], read before the Association of Seismology of the International Union of Geodesy and Geophysics at the Rome meetings, September 1954.

It will be assumed that the reader is familiar with the methods of the research, which have been fully described in earlier papers[1,6,7,8] of the series.

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[5] J. H. Hodgson, "Direction of Faulting in Pacific Earthquakes", *Geofisica Pura e Applicata*, 32, 31-42, 1955.

[6] J. H. Hodgson and R. S. Storey, "Tables Extending Byerley's Fault-Plane Techniques to Earthquakes of Any Focal Depth", *Bull. Seism. Soc. Am.*, 43, 49-61, 1953.

[7] J. H. Hodgson and J. F. J. Allen, "Tables of Extended Distances for PKP and PcP", *Publications of the Dominion Observatory*, 16, 327-348, 1954.

[8] J. H. Hodgson and J. F. J. Allen, "Tables of Extended Distances for PP and pP", *Publications of the Dominion Observatory*, 16, 349-362, 1954.

TABLE 1

LIST OF EARTHQUAKES CONSIDERED

Date	H (G.M.T.)	Epicenter		Focal Depth	Magnitude	Source
		φ	λ			
Earthquakes for which the data were too few to permit a solution						
July 23, 1950	15:50:06	16°S	165°E	0·00R	—	U.S.C. and G.S.
Sept. 10, 1950	15:16:08	15½°S	167°E	0·01R	7·1	Pasadena
Oct. 5, 1950	00:41:07	18½°S	170°E	0·00R	—	U.S.C. and G.S.
Dec. 2, 1950	19:51:49	18¼°S	167½°E	0·01R	7·7	Pasadena
Dec. 3, 1950	07:47:33	17½°S	167°E	0·00R	6·5	U.S.C. and G.S.
June 7, 1951	22:59:00	27½°S	176°W	0·00R	6·7	U.S.C. and G.S.
Aug. 13, 1953	09:23:23	21½°S	170°E	0·02R	6·8	U.S.C. and G.S.
Sept. 17, 1953	21:11:48:	20½°S	174°W	0·01R	6·8	U.S.C. and G.S.
Earthquakes for which the data were sufficient but inconsistent						
May 21, 1951	08:27:21	6°S	154½°E	0·02R	7·0	U.S.C. and G.S.
Dec. 6, 1952	10:41:14	8°S	157°E	0·00R	7·1	U.S.C. and G.S.
Feb. 26, 1953	11:42:26	11°S	164½°E	0·00R	7·2	U.S.C. and G.S.
Nov. 4, 1953	03:49:04	12½°S	166½°E	0·00R	7·3	U.S.C. and G.S.
Earthquakes for which a solution has been obtained						
May 17, 1950	18:13:13	21°S	169°E	0·00R	7·0	Pasadena
May 19A, 1950	02:38:10	20½°S	169°E	0·00R	6·8	U.S.C. and G.S.
May 19B, 1950	07:05:31	20½°S	169°E	0·00R	6·5	U.S.C. and G.S.
May 26, 1950	01:17:25	20¼°S	169¼°E	0·00R	7·1	Pasadena
May 27, 1950	12:39:43	20°S	168°E	0·03R	6·5	U.S.C. and G.S.
May 28, 1950	01:36:44	20°S	169°E	0·00R	6·5	U.S.C. and G.S.
June 21, 1950	06:55:37	20¼°S	169¼°E	0·00R	6·9	Pasadena
June 24, 1950	22:25:34	20½°S	169½°E	0·00R	7·2	Pasadena
July 17, 1950	20:17:50	20½°S	171°E	0·01R	—	U.S.C. and G.S.
July 21, 1950	20:32:01	15½°S	168½°E	0·00R	6·8	U.S.C. and G.S.
July 22, 1950	23:08:00	14°S	167°E	0·00R	—	U.S.C. and G.S.
Feb. 13, 1951	11:55:50	15°S	175°W	0·03R	7	U.S.C. and G.S.
March 23, 1951	21:38:54	31°S	180°	0·04R	7·1	U.S.C. and G.S.
Aug. 28, 1951	16:31:11	27°S	178°E	0·09R	—	U.S.C. and G.S.
Feb. 25, 1952	01:17:00	17°S	173½°W	0·00R	6·9	U.S.C. and G.S.
May 9, 1952	17:47:41	6½°S	155°E	0·01R	7·0	Pasadena
July 13, 1952	11:58:34	18½°S	169½°E	0·05R	7·0	U.S.C. and G.S.
July 27, 1952	08:23:22	20½°S	179°W	0·07R	—	U.S.C. and G.S.
Sept. 11, 1952	22:26:41	29°S	177°W	0·00R	6·8	U.S.C. and G.S.
July 2, 1953	06:56:51	18½°S	169°E	0·03	7·7	U.S.C. and G.S.
Sept. 14, 1953	00:26:36	18½°S	178½°E	0·00	6·7	U.S.C. and G.S.
Sept. 29, 1953	01:36:45	36½°S	177°E	0·04	7·2	U.S.C. and G.S.
Jan. 13, 1954	00:13:06	49°S	165°E	0·00R	7·2	U.S.C. and G.S.

PRESENTATION OF THE DATA

The epicentral data on the earthquakes considered are given in Table I. It is probable that the epicentres are not more accurate than $\pm\frac{1}{2}$ degree, nor the depths than ± 50 km. In the words of Gutenberg and Richter[9] "Location of shocks in this region has always been difficult; it is complicated by the occurrence of shocks in the whole range of shallow and intermediate focus".

It will be noted that in Table I the earthquakes are listed in three groups. For earthquakes in the first group too few data were received to make a solution possible. One of the earthquakes of this group, that of December 2, 1950, has been successfully treated by Webb[10] who worked from original records.

A second group of earthquakes listed in Table I presented sufficient but inconsistent data. Readers familiar with the earlier papers of this series will recall that most solutions have numerous inconsistent observations. These normally do not cause serious difficulty since they fall in among consistent observations in such a way that no mechanism could account for them. The four earthquakes listed in the second group of Table I had large groups of observations consistent among themselves but inconsistent with other groups. No solutions could be obtained and it appears possible that some mechanism other than failure under a couple may be active. It is perhaps significant that all the earthquakes of this group are from the Solomon Islands region.

In order that others may study the mechanism of these shocks all the first-motion data collected are given in Table II, together with distance and azimuth of each contributing station from each of the four epicentres.

The third group of earthquakes consists of those for which solutions have been obtained. These solutions are discussed in the following section; the data on which the solutions depend are given in Table III.

The notation used in Tables II and III is the same as that used in earlier papers. The letters C or D, upper or lower case, are used to indicate a recorded compression or dilatation respectively in place of the letter P in the designation of the phase. Thus a P phase recorded as a dilatation would be reported as "D", a pP_1' phase recorded as a compression would be listed as "cC_1'", and so on. This system works very well except in reporting the phase PcP, where the letter c in the phase designation is confusing. In this case the observation is reported simply by writing "PcP=" in the tables. The phase designations given in the tables are those observed at the stations; reflected phases are plotted with a phase change due to reflection.

Two of the earthquakes listed in Table I occurred on the same day, May 19, 1950. To simplify reference to these two shocks in other tables the dates have been called May 19A and May 19B.

[9] B. Gutenberg and C. F. Richter, *Seismicity of the Earth*, (Princeton, Princeton University Press) p. 48.
[10] J. P. Webb, "A Seismological Study of the Tectonics of a Portion of the Southwest Pacific", Doctoral Dissertation, Saint Louis University, 1954.

TABLE II

Distance, Azimuth and First Motion Data for Four Solomon Islands Earthquakes

A negative sign indicates an azimuth measured west of north.

Earthquake	May 21, 1951			December 6, 1952			February 26, 1953			November 4, 1953		
Station	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion
Aberdeen..........				128·4	−14·4	DD				134·7	−8·7	DD
Alger Unis.........				142·9	−35·8	D_1' CC	149·4	−30·2	C_1'			
Alicante............	140·6	−31·6	C_1' DD	143·6	−30·5	C_1' CC	149·7	−23·8	C_1' CC	151·8	−22·0	C_1' CC
Almeria............	142·8	−31·3	D_1' DD	145·8	−30·0	C_1'	151·8	−22·5	C_1' CC	153·9	−20·4	D_1' DD
Apia................				31·2	103·3	D dD				21·2	95·7	C
Arcata..............	87·5	48·6	D dD									
Athens..............				128·5	−47·3	D_1'				138·3	−46·0	D_1'(?) DD(?)
Auckland...........				32·9	153·2	D(?) DD				25·3	164·3	C
Bandung............				48·9	−92·1	cC	56·2	−90·9	D	58·2	−90·3	D
Basel...............	129·9	−28·8	C_1' CC				138·8	−23·8	D_1'	140·9	−22·8	C_1'(?) CC
Belgrade............				127·5	−38·1	D_1'	134·4	−35·8	C_1'	136·8	−35·5	C_1'
Berkeley............	88·3	51·8	C cC	87·6	51·4	C	83·8	49·7	C	83·3	49·0	C
Bermuda-Columbia.							130·1	56·9	CC	129·3	58·4	C_1' CC
Bogota..............	131·6	89·2	DD	129·2	90·6	C_1'						
Bombay............	84·1	−70·3	D	87·1	−70·6	C						
Bozeman...........							94·0	44·4	C			
Brisbane............	21·4	−176·4	C(?)	19·7	−169·5	D	19·6	−148·2	D	19·5	−141·6	D DD
Budapest...........	123·9	−35·0	DD(?)				133·5	−32·0	D_1'(?) CC	135·8	−31·6	D_1' CC
Butte...............							93·0	43·8	D(?)	92·8	43·6	C
Calcutta............	70·6	−63·7	C	73·7	−63·8	C	81·7	−65·1	C			
Cartuja.............	143·1	−29·8	C_1' DD cC_1'	146·1	−28·4	C_1' DD cC_1'	151·9	−20·4	D_1'	153·9	−18·2	C_1'
Chicago.............							110·6	49·5	DD			
Chinchina...........										118·3	91·1	DD
Christchurch........	40·6	159·7	D	37·9	161·4	C	33·1	169·2	D	31·3	171·4	C
Cincinnati..........	117·6	48·8	C_1' dD_1'	117·1	50·1	DD(?)				112·5	52·7	D(?)
Cleveland...........							115·2	49·4	DD			

TABLE II—*Continued*

Distance, Azimuth and First Motion Data for Four Solomon Islands Earthquakes—*Continued*

A negative sign indicates an azimuth measured west of north.

Earthquake	May 21, 1951			December 6, 1952			February 26, 1953			November 4, 1953		
Station	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion
Cobb River	38·5	157·7	C	35·7	159·5	C				28·9	170·2	C
Coimbra							150·3	−11·0	D_1'			
College	82·4	21·2	D	83·4	20·7	D						
Collmberg	124·7	−28·4	C_1'	127·7	−27·8	D_1' CC				135·8	−23·7	D_1' DD
Copenhagen	122·0	−24·3	C_1'	124·9	−23·6	C_1	130·4	−20·4	D_1'	132·5	−19·6	D_1' CC
De Bilt			CC									
Djakarta				49·8	−91·2	C dD dDD	57·2	−90·2	C DD	59·1	−89·7	D CC
Firenze										142·3	−29·8	C_1'
Fresno	90·1	53·2	C	89·4	52·9	C	85·4	51·3	C	84·8	50·7	C
Fukuoko	45·6	−28·5	C	48·5	−30·0	D	55·0	−34·9	D	57·4	−35·8	C
Halifax										126·8	43·2	D_1'
Helwan				124·8	−59·3	D_1'				135·1	−60·2	D_1'
Hiroshima										56·8	−33·6	C
Hong Kong				51·7	−53·4	C	59·5	−55·9	D	61·9	−56·2	C
Honolulu	54·1	58·4	C	53·1	55·8	C	49·0	49·0	D			
Hungry Horse	95·4	42·1	C cC				92·6	41·3	C	92·4	41·0	D
Hyderabad	78·6	−70·9	C	81·6	−71·0	C	89·6	−72·2	C	91·9	−72·7	C
Karapiro				34·1	153·4	C DD	28·5	161·5	C DD	26·5	163·8	D
Karlsruhe	128·5	−28·0	D_1 DD	131·4	−27·2	C_1' CC	137·3	−23·2	CC	139·4	−22·2	D_1' DD
Kew				132·8	−19·2	C_1'						
Kiamata	39·3	160·1	D	36·6	162·0	D	31·9	170·3	D	30·1	172·8	C cC CC
Kiruna				113·7	−16·5	C_1'						
Kobe										55·6	−31·3	C
Kochi				47·0	−27·0	D	53·3	−32·4	D			
Kodaikanal	78·4	−78·3	C	81·2	−78·3	D	89·1	−79·5	C	91·3	−79·9	C
La Paz				129·1	118·8	C_1' CC	121·2	117·0	D_1' DD	118·7	116·8	C_1' CC
Lincoln				107·6	49·8	CC				103·3	50·7	C
Lisbon				147·0	−20·1	C_1'	151·9	−10·6	C_1'			

TABLE II—*Continued*

Distance, Azimuth and First Motion Data for Four Solomon Islands Earthquakes—*Continued*

A negative sign indicates an azimuth measured west of north.

Earthquake	May 21, 1951			December 6, 1952			February 26, 1953			November 4, 1953		
Station	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion
Malaga	143·9	−29·4	D_1' DD	146·8	−27·9	C_1'						
Manilla				42·2	−57·9	D	50·1	−60·4	D	52·5	−60·5	D
Matsushiro				47·7	−20·5	C				55·7	−27·5	C
Messina				134·1	−43·1	C_1'						
Mineral	89·2	49·5	C				85·1	47·5	C	84·7	46·8	C
Mount Hamilton	88·8	52·4	C cC DD	88·0	52·0	C CC	84·1	50·3	C CC	83·6	49·7	C
Mount Wilson	91·3	55·9	C									
Nemuro										58·8	−17·7	C
New Delhi				85·0	−60·3	D						
New Plymouth				34·5	156·2	D CC	29·2	164·6	D CC	27·2	167·1	D
Osaka										55·4	−31·1	C
Ottawa	121·5	39·4	C_1'	121·4	41·1	D_1'				118·3	45·1	CC
Palomar	92·1	56·9	C				86·7	55·3	C			
Pasadena	91·1	56·0	C	90·2	55·7	C	85·9	54·2	C	85·2	53·6	C
Pierce Ferry	94·7	54·3	C									
Prague				127·8	−29·7	D_1'	133·9	−26·5	CC	136·2	−25·8	C_1'
Pretoria				120·0	−125·8	C_1'						
Quetta				94·0	−60·2	C						
Rathfarnham				132·9	−13·6	C_1'	137·2	−8·1	C_1'	138·9	−6·6	C_1' CC
Reno	90·5	50·5	C	89·9	50·2	C DD	86·2	48·7	C	85·7	48·1	C PcP=C
Resolute Bay	101·2	14·7	C dD DD	102·5	15·0	C CC						
Reykjavik	122	−1·9	D_1'									
Riverside	91·8	56·2	C	90·8	55·9	D	86·5	54·5	C	85·8	54·0	C
Riverview	27·8	−174·0	C cC	26·2	−169·0	D CC	25·7	−153·8	D dD PcP=D	25·3	−149·1	C cC
Rome	130·9	−37·4	C_1'	134·0	−37·0	C_1'						
Salt Lake City							92·4	49·1	DD			
San Juan	138·6	69·1	C_1'	136·9	71·8	C_1'(?)						
Santa Clara	88·5	52·4	C dD	87·8	52·0	D	83·9	50·2	D	83·4	49·6	C

TABLE II—*Concluded*

Distance, Azimuth and First Motion Data for Four Solomon Islands Earthquakes—*Concluded*

A negative sign indicates an azimuth measured west of north.

Earthquake	May 21, 1951			December 6, 1952			February 26, 1953			November 4, 1953		
Station	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion	Dist.°	Az.°	Motion
Sapporo							57·9	−19·9	C PcP=C	60·0	−21·1	C
Saskatoon				100·2	38·5	C						
Scoresby-Sund	115·6	−1·3	CC									
Seattle	89·8	42·2	C									
Sendai	45·9	−14·9	D	48·5	−17·0	C	53·8	−23·0	C	56·0	−24·2	D
Seven Falls										121·2	42·2	D_1'
Shasta	88·7	49·0	C dD									
Sitka	84·4	31·1	D dD									
Stuttgart	128·3	−28·7	C_1'(?)									
Suva										12·8	117·1	D
Tamanrasset	145·8	−57·7	D_1' CC									
Tananarive							111·1	−115·3	C_1'(?)			
Tinemaha	91·4	53·0	C				86·6	51·4	C	86·0	50·8	C
Tokyo	43·8	−17·4	C	46·4	−19·4	C(?)	52·0	−25·6	C(?)	54·3	−26·8	C DD
Trieste				131·0	−33·8	C_1' CC(?)				139·7	−29·8	C_1'(?)
Tuai	38·5	151·1	C	35·6	152·5	C						
Tucson	97·1	58·3	C dD				91·4	57·6	C	90·5	57·2	C
Uccle										139·2	−17·3	D_1'
Ukiah				87·2	50·0	D						
Uppsala	117·2	−22·8	CC	120·0	−22·3	DD						
Victoria							86·7	39·3	D	86·6	38·8	D DD
Wellington	39·5	155·8	D	36·7	157·4	D	31·4	165·1	D	29·5	167·3	D
Weston							122·5	46·6	D_1'	122·0	47·7	D_1'
Witteveen				129·3	−22·8	D_1'						
Zurich				132·5	−28·9	C_1'(?)				140·7	−23·8	D_1'(?)

TABLE III

Data on which the Solutions are Based

STATION	May 17, 1950	May 19A, 1950	May 19B, 1950	May 26, 1950	May 27, 1950	May 28, 1950	June 21, 1950	June 24, 1950	July 17, 1950	July 21, 1950	July 22, 1950	Feb. 13, 1951	March 23, 1951	August 28, 1951	Feb. 25, 1952	May 9, 1952	July 13, 1952	July 27, 1952	Sept. 11, 1952	July 2, 1953	Sept. 14, 1953	Sept. 29, 1953	Jan. 13, 1954
Aberdeen	—	(D_1') CC	—	(D_1')	—	—	(D_1')	(D_1')	—	—	—	(dD_1')	—	—	CC	—	—	DD	—	—	(D_1')	C_1' dD_1' DD	DD
Algers Univ.	(D_1') D_2' CC	D_2'	—	DD	—	—	—	C_1' DD	C_2'	(D_1') (CC)	(D_1') (D_2')	cC_1'	—	(D_1') (C_2')	D_1' (DD)	—	C_1' CC	D_1' (DD)	(D_1')	—	—	—	—
Alicante	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C_1'	C_1' DD	D_1' (DD)	(D_1') CC	—
Almeria	C_1'	D_1'	—	—	—	—	—	—	—	—	—	D_1'	D_1'	D_1'	—	(D_1')	C_1'	C_1'	C_1'	C_1'	(C_1')	C_1'	—
Apia	D	—	—	—	—	D	—	—	—	D	—	(D)	C	—	D	—	(D)	(C)	—	C	C	C	—
Arapuni	C (CC)	(D)	—	C DD	—	(D)	C	—	(C)	C	—	—	—	—	—	—	—	—	—	—	—	—	—
Arcata	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(C)	—	—	—	—	—	—	—
Athens	C_1'	D_1'	—	C_1'	—	—	—	C_1'	—	—	—	—	(D_1')	—	C_1' C_2'	C_1' (cC_1')	C_1'	—	—	C_1'	D_1'	(C_1')	C_1'
Auckland	C	C	C	—	D	C	C	C	D	C	(D)	—	D	(C)	D	D	D	—	C	D dD	D	D	—
Basel	C_1'	(D_1')	—	C_1' (DD)	(D_1')	D_1'	—	—	C_1'	C_1' CC	—	D_1' cC_1'	D_1' C_2'	C_1'	C_1' CC	C_1' (CC)	C_1'	D_1'	C_1'	C_1' cC_1'	D_1' (DD)	(D_1') cC_1'	C_1' D_2' (DD)
Belgrade	C'	(C_1')	—	(D_1')	—	D_1'	C_1'	C_1'	—	(D_1')	—	—	C_1'	—	—	—	(D_1')	(C_1')	C_1'	(D_1')	D_1'	D_1'	—
Berkeley	C	D	D	C	C	(C)	C	C	C	(D)	D	D	D	—	—	D	C CC	C cC	C	C DD cC	—	C dD	CC
Bermuda	—	—	—	CC	—	—	(CC)	(CC)	—	CC	—	—	—	—	—	C_1'	—	—	—	C_1' (CC)	—	C_1' CC	D_1' CC
Besançon	—	—	—	—	—	—	—	—	—	—	—	(dD_1')	—	—	—	—	—	—	—	—	—	—	—
Bidston	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C_1'	C_1'	—	—	—	—	—	—	—
Bogota	—	DD	—	DD	—	—	—	(CC)	—	(CC)	—	—	—	—	(C)	C_1'	—	—	—	C_1'	—	(DD)	—
Bologna	C_1'	C_1'	—	C_1'	—	—	C_1'	C_1'	C_1'	(D_1')	—	—	—	—	(D_2')	C_1'	—	—	—	—	—	—	—

Bombay	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(C_1')	—	—	—	(C_1')	—
Boulder City	C	C	C	C	C	D	C	C	C	C	—	—	—	—	—	—	—	—	—	—	—	—	—
Bozeman	—	—	—	—	—	—	—	—	—	(D)	—	—	—	—	—	—	C	C	—	(D)	C	C	—
Brisbane	D	—	D	D	(D)	D (DD)	D	—	D	C	C	—	D	C	C	(D)	—	D	C	D	C	D	C
Budapest	C_1'	D_1'	—	C_1'	—	D_1'	(D_1')	(D_1')	—	—	—	D_1'	—	—	C_1' (D_2')	—	—	(C_1')	—	—	D_1'	D_1'	D_2'
Butte	—	—	—	—	—	—	—	—	—	—	—	—	—	(dD)	C	—	C	C	(D)	C	D	—	—
Calcutta	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(CC)	C	—	—	—	C	—	—	—
Cartuja	C_1' CC	DD	—	(D_1') CC	(D_1') DD	—	(D_1') DD	(D_1') (DD)	(D_1') CC	C_1' CC	D_1' DD	C_1' (DD) cC_1'	D_1' D_2' (DD) cC_1'	—	—	C_1' DD dD_1'	C_1' (DD) dD_1'	C_1' CC (cC_1')	D_1' C_2'	(D_1') C_2' (dD_1') (CC)	D_1' (C_2') CC	C_1' (D_2') cC_1' (cC_2') DD	—
Cheb	—	—	—	—	—	—	—	—	—	—	—	D_1'	—	—	—	—	(D_1') dD_1'	—	—	—	D_1' (C_1')	—	—
Chicago-Loyola	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	DD	—	—	—	—	—	—
Chicago-U.S.C.G.S.	—	—	—	—	—	—	—	C_1'	—	—	—	—	—	—	—	—	DD	C CC	—	—	—	DD	—
China Lake	—	—	—	—	—	D	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Chinchina	—	—	—	—	—	—	—	—	—	—	—	C	CC	—	DD	C_1'	—	—	—	—	—	—	—
Christchurch	C	—	C (CC)	C	C	C	C	C	D (DD)	C CC	—	D	C	C	—	C	D	—	—	(C)	D	C	C
Chur	—	—	—	—	—	—	—	—	—	—	—	D_1'	—	—	—	C_1'	C_1'	D_1'	—	C_1'	D_1'	—	—
Cincinnati	—	—	—	—	—	(C)	—	—	—	C CC	—	C (dD)	D_1'	—	D	CC	—	C	(CC)	C DD cC	—	(D_1') cC_1'	—
Cleveland	(D) C_1'	—	—	C CC (D_1')	—	—	CC	C_1' CC	—	CC	(DD)	C	D_1' dD	—	—	(D_1')	C_1'	—	—	C (D_1')	DD	C_1' DD cC_1'	—
Cobb River	C	(D)	—	—	—	—	(D)	—	(C)	(D) CC	—	D	C	C	(C)	C	D	C	—	D	(C)	C	C
Coimbra	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C_1' (D_2')	—	D_1' (CC)	—
College	C	C	D	D	(D)	D	C	D	D	D	D	(C)	C	D (dD)	D	—	D	D	D	—	—	—	—
Collmberg	—	—	—	—	—	—	—	—	—	—	—	D_1' (C_2')	C_1' DD cC_1'	D_1' D_2' cC_1'	—	C_1' DD	(D_1') (DD)	—	(C_2')	C_1' DD	D_1' D_2' (DD)	C_1' DD	C_1' C_2' CC

TABLE III—*Continued*

Data on which the Solutions are Based

STATION	May 17, 1950	May 19A, 1950	May 19B, 1950	May 26, 1950	May 27, 1950	May 28, 1950	June 21, 1950	June 24, 1950	July 17, 1950	July 21, 1950	July 22, 1950	Feb. 13, 1951	March 23, 1951	August 28, 1951	Feb. 25, 1952	May 9, 1952	July 13, 1952	July 27, 1952	Sept. 11, 1952	July 2, 1953	Sept. 14, 1953	Sept. 29, 1953	Jan. 13, 1954
Colombo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—	D	—	—	—
Copenhagen	(D_1')	(D_1')	CC	C_1'	(D_1')	—	—	—	C_1	—	—	D_1'	C_1' C_2' (CC)	—	—	—	—	D_1'	—	—	C_1' cC_1'	(D_2')	—
De Bilt	C_1' CC	C_1' CC	C_1'	C_1' CC	C_1'	D_1'	C_1'	C_1' CC	—	(D_1')	(C_1')	D_1' (dD_1')	—	—	—	—	—	—	—	—	—	—	—
Djakarta	—	—	—	—	—	—	—	—	C	—	—	—	—	—	—	C	—	D	—	D DD dD	(D)	C CC cC	D CC
Fayetteville	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—	C	—	C	—	—	—
Finger Bay	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	D	—	—	—	—
Florence	—	—	—	—	—	—	—	—	—	—	—	D_1'	—	—	C_1'	—	—	—	(D_1')	—	(C_1') (dD_1')	C_1' CC dD_1'	—
Fresno	—	—	—	—	—	—	—	—	—	—	—	(C)	D	C cC	C	C	C	C	C dD	C DD	—	—	—
Fukuoko	C	—	—	C	—	—	D	C	—	—	—	C	—	—	—	D	(C)	—	—	C	—	C	C
Grahamstown	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(C_1')	—	—	C
Halifax	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C_1'	C_1' cC_1'	—	C_1'	D_1'
Harvard	C_1'	C_1' CC	CC	C (D_1')	C_1'	D_1' (DD)	C_1' CC	C_1' DD	—	CC	—	—	—	—	—	C_1'	—	—	—	—	—	—	—
Helwan	—	—	—	C_1'	—	—	C_1'	C_1'	D_1'	(D_1')		C_1'	—	—	(D_1')	—	—	(C_1')	—	C_1'	—	—	—
Hiroshima	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—	—
Hong Kong	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—	—	C	—	(C) (dD) CC	—
Honolulu	(C)	(C)	—	D	—	—	—	(C)	—	(C)	—	D	C	—	D	D	D	D	D	C	—	C	—

Hungry Horse	C	C	—	C	—	—	—	(D)	(D)	C	—	D	D	—	C	—	C	(D)	—	C	(C)	—	—
Hyderabad	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(D)	—	—	—	—	(C)	CC
Ivigtut	(D_1')	D_1'	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kalocsa	(D_1')	—	—	—	—	—	—	(D_1')	—	—	—	—	—	—	—	C'	—	(C_1')	—	—	—	—	—
Karapiro	—	—	—	—	—	—	—	—	—	—	—	—	—	D	D	(C)	—	(D)	C	D	D (DD)	C	C
Karlsruhe	—	—	—	C_1'	—	D_1'	C_1'	—	—	—	—	D_1' dD_1'	D_1'	—	(D_1') CC	(cC_1')	(D_1') CC	—	—	C_1' cC_1'	D_1' (dD_1')	(D_1') C_2'	(D_1') D_2' CC
Kecskemet	—	—	—	—	—	—	C_1' CC	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Kew	C_1'	C_1'	(D_1') DD	C_1' CC	(D_1')	D_1'	—	C_1' (DD)	—	D_1'	—	—	—	—	C_1'	—	C_1'	—	—	—	C_1'	—	—
Kiamata	(D)	C	C	(D)	—	—	—	C	D	C	—	D	C	C	D	(D)	D	D	D	D	D	—	C
Kimberley	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C_1'	C_1'	—	—	(C_1')	—	—	—
Kirkland Lake	—	—	—	—	—	—	—	—	—	—	—				D_1'	(D_1')	(D_1')	(DD)				C_1'	C_1'
Kiruna	—	—	—	—	—	—	—	—	—	—	—	—	—	CC	C_1' CC	C_1'	CC	—	—	C_1'	—	C_1'	C_1'
Kodaikanal	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	D	—	—	—
Koti	C	—	—	(D)	—	—	D	C	—	C	—	—	—	—	—	D	—	D	—	C	—	(D)	—
Ksara	C_1'	D_1' (DD)	D_1'	(D_1') CC	D_1'	C_1' CC	C_1'	C_1'	D_1'	(D_1')	CC	—	—	—	C_1'	—	—	—	—	—	—	—	—
La Paz	(CC)	C (CC)	C (CC)	C DD	D CC	(DD)	(D) (CC)	C (CC)	—	C (CC)	—	—	D (DD)	—	(DD)	(D_1')	—	(CC)	—	C CC	C DD	(C) CC	CC
La Plata	—	—	—	—	—	—		—	—	—	—	—	CC	—	—	—	—	—	—	D_1'	—	—	PcP=C
Lincoln	—	—	—	—	—	—	—	—	—	—	—	C	—	—	—	—	C	—	—	—	—	—	—
Lisbon	C_1' CC	—	—	C_1' CC	—	—	C_1' CC	C_1' CC	—	—	—	—	D_1' D_2'	—	D_1'	C_1' (D_2')	—	—	—	C_1' (D_2') (dD_1') cC_2'	C_1' D_2'	C_1' D_2' cC_1' (dD_2')	C_2'
Lwiro	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C_1' CC
Malaga	—	—	—	—	—	—	—	—	—	—	—	C_1' CC	—	(C_1') (C_2')	D_1' CC	C_1' DD	(D_1')	C_1' CC	D_1' DD	—	—	—	—
Manilla	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(D)	D	—	(D)	C	D	—
Matsushiro	—	—	—	—	—	—	—	—	—	—	—	—	—	—	D	(C)	D DD	DD	—	C	C	C	C DD

TABLE III—*Continued*

Data on which the Solutions are Based

STATION	May 17, 1950	May 19A, 1950	May 19B, 1950	May 26, 1950	May 27, 1950	May 28, 1950	June 21, 1950	June 24, 1950	July 17, 1950	July 21 1950	July 22, 1950	Feb. 13, 1951	March 23, 1951	August 28, 1951	Feb. 25, 1952	May 9, 1952	July 13, 1952	July 27, 1952	Sept. 11, 1952	July 2, 1953	Sept. 14, 1953	Sept. 29, 1953	Jan. 13, 1954
Messina	C_1'	—	—	C_1'	—	—	—	C_1'	—	—	C_1'	—	—	—	(D_1')	—	—	—	—	C_1'	—	—	—
Mineral	—	—	—	—	—	—	—	—	—	—	—	D	(C)	D	—	—	C DD (cC)	C cC	C dD	C DD	D	C	CC
Mount Hamilton	C	D	C	C	C	D	C	C	C	C CC	D	D (DD)	D	C cC	C	C	C (CC)	C (dD)	(D) dD	C DD cC	C	C	—
Mount Wilson	—	—	—	—	—	—	—	—	—	—	—	D	D	C	C	C	C	C		C	—	C	—
Nagoya	C	—	—	C	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Nemuro	—	—	—	—	—	—	—		—	—	—	—	—	—	—	—	—	D	—	—	—	—	—
New Plymouth	C	C	—	—	—	—	—	—	—	(D)	—	D	D	(D)	—	D	C	D	—	(C)	(C)	—	C
New York C.C.	—	—	—	—	—	—	D_1'	(D_1')	—	(DD)	—	—	—	—	—	—	—	—	—	—	—	—	—
Osaka	C	—	—	—	—	C	C	C	—	—	C	—	—	—	—	—	—	—	—	—	—	—	—
Ottawa	C_1'	—	—	—	—	—	C_1' CC	C_1' CC	—	—	—	D_1'	—	cC_1'	—	—	C_1' CC	—	—	C_1'	—	—	C_1'
Palo Alto	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C		(D)	—
Palomar	—	—	—	—	—	—	—	—	—	—	—	D	D	C	C	—	C	C	—	C	—	C	—
Paris	(D_1')	(D_1')	—	(D_1') (DD)	(D_1')	(C_1') CC	(D_1') CC	C_1' (DD)	(D_1')	(D_1')	D_1'	—	—	—	—	—	—	—	—	—	—	—	—
Pasadena	C	C	C	C	C	—	C	C	C	C		D	D	C	C	C	C DD	C	C	C	(D)	C cC	—
Pavia	C_1'	—	—	(D_1') D_2'	—	D_1'	(D_1')	C_1'	C_1'	C_1'	—	(C_1') cC_1'	C_2'	—	(D_1') (D_2')	C_1'	—	—	—	C_1'	—	cC_1'	—
Perth	—	(C)	—	(C) CC	—	—	(C)	(C)	—	—	—	—	—	—	—	—	—	—	—	—	—	—	D (DD) PcP=C
Philadelphia	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(CC)	—	—	—	—	DD	—
Pierce Ferry	—	—	—	—	—	—	—	—	—	—	—	(C)	D	(D)	(D)	—	—	—	—	—	—	—	—

Prague	—	C_1'	C_1'	C_1'	—	—	C_1'	C_1'	—	—	—	D_1'	C_1' (D_2')	—	C_1'	D_1' (cC_1')	C_1'	D_1' D_2'	D_2'	C_1'	D_1'	C_1' C_2' DD cC_1' cC_2'	—
Prato	(D_1')	—	—	C_1'	—	—	(D_1')	(D_1')	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Pretoria	—	—	—	—	—	—	—	—	C_1'	—	—	—	—	—	—	—	(D_1')	—	—	—	—	—	—
Quetta	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C_1'	—	—	—
Rapid City	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	C	—	—
Rathfarnham	C_1'	C_1'	—	C_1' CC	C_1'	(C_1')	C_1'	C_1'	—	D_1'	—	—	D_1' (D_2')	D_1'	—	—	C_1'	—	C_1'	C_1' cC_1'	C_1' (DD)	(D_1')	—
Reno	—	—	—	—	—	—	—	—	—	—	—	D	—	—	—	C	C DD	C CC	C cC	C	—	—	—
Resolute Bay	—	—	—	—	—	—	—	—	—	—	—	D CC	(C_1') (CC)	—	C DD cC	D dD	—	—	—	C C_1'	—	(D_1')	C_1'
Reykjavik	—	—	—	—	—	—	—	—	—	—	—	—	D_1'	—	—	—	C_1' CC	—	—	—	—	C_1'	—
Riverside	—	—	—	—	—	—	—	—	—	—	—	D	D	C	C	C	C	C	—	C	C	C	—
Riverview	D (DD)	D CC	D DDD	D DD (dD)	C	C DD	D CC	D CC	D CC dD	C (dD)	C	D CC cC	D (DD) cC	—	C (cC)	C	C DD dD	D (dD)	C (CC) DD	D cC	D (DD) cC	D cC	(D) (cC)
Rome	—	C_1' CC	C_1'	C_1' (DD)	D_1'	D_1' DD	C_1' (DD)	C_1'	C_1'	C_1'	C_1'	—	—	—	C_1'	C_1'	C_1'	—	—	C_1'	—	—	—
Salo	C_1'	C_1'	—	C_1'	C_1'	—	—	—	—	—	—	D_1'	—	—	—	—	—	—	—	—	—	cC_1'	—
Salt Lake City	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—	C	—	—	C	C	—	—
San Juan	—	—	DD	—	—	CC	CC	(D_1') DD	—	C_1'	—	—	(C_1')	C_1'	—	—	C_1'	C_1' (CC)	—	C_1'	—	(C_1')	—
Santa Clara	(D)	(C)	—	C CC	—	—	(D)	(D)	—	C	(C)	(C)	(C)	—	—	—	(D)	(D)	C	—	D	—	—
Sapporo	—	—	—	—	—	—	—	—	—	—	—	—	C	(C)	—	—	D	D	D	C CC cC	C PcP=D	C	—
Saskatoon	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—	—
Scoresby Sund	—	—	—	—	—	—	—	—	—	—	—	CC	DD	—	—	—	—	—	—	—	—	—	—
Seattle	—	—	—	—	—	—	—	—	—	D	—	D	D	D	—	—	C	—	—	—	—	—	—
Sendai	C	—	—	D	—	—	C	C	—	D	—	D	(D)	—	—	—	(C)	D	—	C	(D)	C	C
Seven Falls	—	—	—	—	—	—	—	—	—	—	—	—	D_1'	—	—	—	—	—	—	C_1'	—	—	—

TABLE III—*Concluded*

Data on which the Solutions are Based

STATION	May 17, 1950	May 19A, 1950	May 19B, 1950	May 26, 1950	May 27, 1950	May 28, 1950	June 21, 1950	June 24, 1950	July 17, 1950	July 21, 1950	July 22, 1950	Feb. 13, 1951	March 23, 1951	August 28, 1951	Feb. 25, 1952	May 9, 1952	July 13, 1952	July 27, 1952	Sept. 11, 1952	July 2, 1953	Sept. 14, 1953	Sept. 29, 1953	Jan. 13, 1954
Shasta	C	C	D	C	C	D	C	C	C	C	—	D	D	D cC	C	—	—	—	—	C CC	D	C	—
Shawinigan Falls	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C_1'	—	—	—
Shillong	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	—	—	—	C	—	—	—
Sitka	—	—	—	—	—	—	—	C	—	(C)	—	—	—	—	—	D	D	C	—	D	—	—	—
State College	CC	(DD)	—	C_1'	—	—	—	C_1'	—	CC	—	—	—	—	—	—	—	—	—	—	—	—	—
Strasbourg	C_1'	C_1' CC	C_1' C_1'	C_1' C_2' CC	(D_1') CC	D_1'	C_1' CC	C_1'	C_1' CC	(D_1')	D_1'	D_1'	(C_1')	—	C_1'	(D_1')	C_1'	D_1'	C_1'	C_1'	—	C_1'	—
Stuttgart	C_1'	C_1'	C_1' D_2'	C_1'	C_1'	D_1' D_2'	C_1'	C_1'	—	C_1'	C_1'	D_1' cC_1'	D_1' DD	—	C_1'	C_1'	C_1' (cC_1')	D_1'	C_1'	C_1' cC_1'	D_1'	(dD_1')	—
Suva	—	—	—	D	D	—	D	D	(D)	D	D	—	(D)	—	—	—	—	—	—	—	(C)	C	C DD
Tacubaya	DD	—	—	(D)	—	—	DD	—	—	—	—	—	—	—	(D)	—	(D)	—	—	C	—	—	—
Tamanrasset	C_1' D_2' CC	C_1' D_2' CC	—	C_1' D_2'	D_1' D_2'	C_1' C_2' DD	C_1' D_2' (DD)	C_1' D_2' (DD)	C_1' C_2' DD	C_2' DD	C_1' D_2' (DD)	C_1' D_2'	(C_1') (dD_1')	D_1' C_2'	D_1' DD	(D_1') DD	(D_1')	C_1' CC	—	—	—	—	—
Tananarive	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	cC
Tinemaha	—	—	—	—	—	—	—	—	—	—	—	D	(C)	—	C	C	C	C	—	C	(D)	C	—
Tokyo	C	—	—	C DD	—	—	C	C DD	—	D	—	—	—	—	—	—	—	D	—	C DD (dD)	—	—	—
Toledo	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C_1'	—	—	C_1'	—	—	—
Tortosa	C_1'	C_1'	C_2'	C_1'	—	—	C_1'	C_1'	—	C_1'	C_1'	—	—	—	—	—	—	—	—	—	—	—	—
Trieste	—	—	—	—	—	—	—	—	—	—	—	(C_2')	C_1'	C_1' CC	C_1' C_2'	C_1'	C_1' C_2'	D_1' (C_2')	C_1'	C_1'	(C_1')	C_1' (C_2')	C_1' D_2' (DD)
Tuai	(D)	C	C	—	D	C	C	—	D	C	—	—	(D)	—	(C)	D	D	—	—	C	D	C	D

Tucson	C	C	C	C	C	—	—	C CC	C	C	—	C	D	C dD	C	C	C	C	D	C	C	C	—
Uccle	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	C	cC_1'	—
Ukiah	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	(D)	—	—	(D)	—	—	—
Uppsala	—	—	(CC)	(DD)	—	—	—	CC	—	CC	—	—	C_1'	—	C_1'	C_1'	CC	D_1'	C_1'	(CC)	(DD)	—	(CC)
Victoria	C	—	—	—	—	—	—	C	C	—	—	(C)	D	—	C	—	C	C cC	—	C	—	—	—
Wellington	C	C	C	C	C	C	C	C	D	C	—	D	C	C	C	—	—	—	D	D	D	C	D
Weston	C_1' CC	C_1'	CC	(D_1') CC	(D_1')	(C_1') CC	C_1' CC	C_1' DD	(D_1')	CC	D_1'	—	—	—	D_1'	—	(D_1')	—	—	C_1'	C_1'	(D_1')	—
Witteveen	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	D_1'	(D_1')	—
Zurich	C_1'	C_1'	—	C_1' C_2'	C_1'	(C_1')	C_1' CC	C_1' C_2'	C_1'	C_1'	(D_1')	D_1' cC_1'	(C_1') (CC)	C_1'	C_1'	(D_1')	C_1'	D_1'	—	C_1' cC_1'	D_1'	C_1' (dD_1')	D_2'

71369—3

ANALYSIS OF THE DATA

In this section solutions will be presented for each of the twenty-three earthquakes for which it has been possible to obtain them. In each case the solution diagram will be given, together with a table showing the number of observations of each sort of phase which were available and the number of these inconsistent with the published solution. The more serious of the inconsistencies will be discussed and, finally, a discussion will be given on any geological implications of the solution which seem pertinent.

The solutions are based on the tables of extended distances already published by this Observatory[6,7,8], as well as on tables not yet published,* giving extended distances for the phase pP′.

Earthquake of 18:13:13, May 17, 1950. $\phi = 21°S$, $\lambda = 169°E$

As shown in Table IV, there are a total of 13 inconsistencies out of 71 observations. Of these the 6 inconsistent observations of P_1' and the 3 of PP are so scattered throughout the diagram that they could not be brought into the solution by any system of circles. Of the 4 inconsistent observations of P, that of Honolulu is described as a "poor" reading. The two inconsistent observations in New Zealand appear more serious. That at Kiamata was described as a questionable dilatation followed by a certain compression, while that at Tuai was described as a certain dilatation followed by a larger compression. There is a temptation to bring at least Kiamata into the solution by adjusting the position of circle *a*, but this, in turn, would make the Japanese stations inconsistent. The present positions of the circles reduce the number of inconsistencies to a minimum and cannot be far from correct.

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* Note added in proof. These tables have now been issued. See *Publications of the Dominion Observatory*, 18 83-100, 1956.

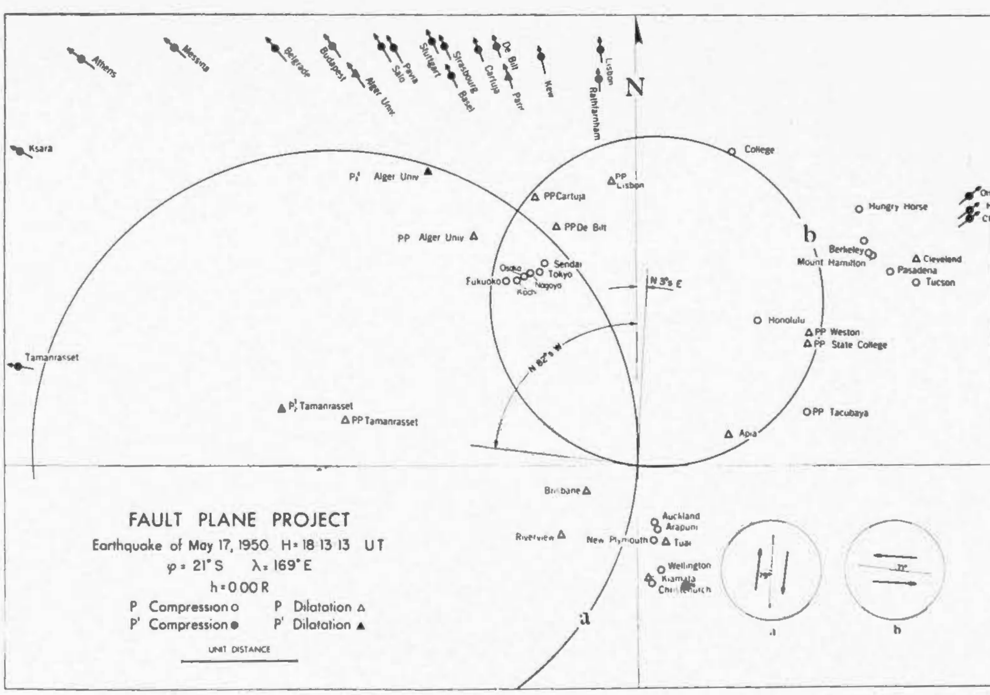


FIGURE 1.

TABLE IV

	P	P_1'	P_2'	PP	Total
Total Number of Observations..................	28	30	2	11	71
Number of Inconsistent Observations............	4	6	0	3	13

The solution, as shown in the insert diagrams, represents two planes, one striking N 3°.5 E and dipping 79° to the west, the other striking N 82°.5W and dipping 71° to the north. Whichever of these planes represents the fault, faulting is strongly transcurrent, with a slight thrust component. There is no appreciable variation permitted in the position of the planes if we accept the points on which the solution is based.

It is worth pointing out that in this case, where the dip component is a thrust, the circles contain dilatations. If the circles contain compressions the dip component is tensional. This is a very helpful rule to follow in interpreting the fault-plane solution diagrams.

Earthquake of 02:38:10, May 19, 1950. $\phi=20\frac{1}{2}$°S, $\lambda=169$°E

In this earthquake it was not clear at first whether the field defined by the P′ observations was dilatational or compressional. However, when the P′ observations were plotted on a reduced scale, as shown in the insert diagram, it was found that all but 5 of the 23 observations of this phase could be made consistent by drawing a very large dilatational circle. Of the three inconsistent observations, that of Basel was described as uncertain.

TABLE V

	P	P_1'	P_2'	PP	Total
Total Number of Observations..................	19	23	2	12	56
Number of Inconsistent Observations............	4	5	0	3	12

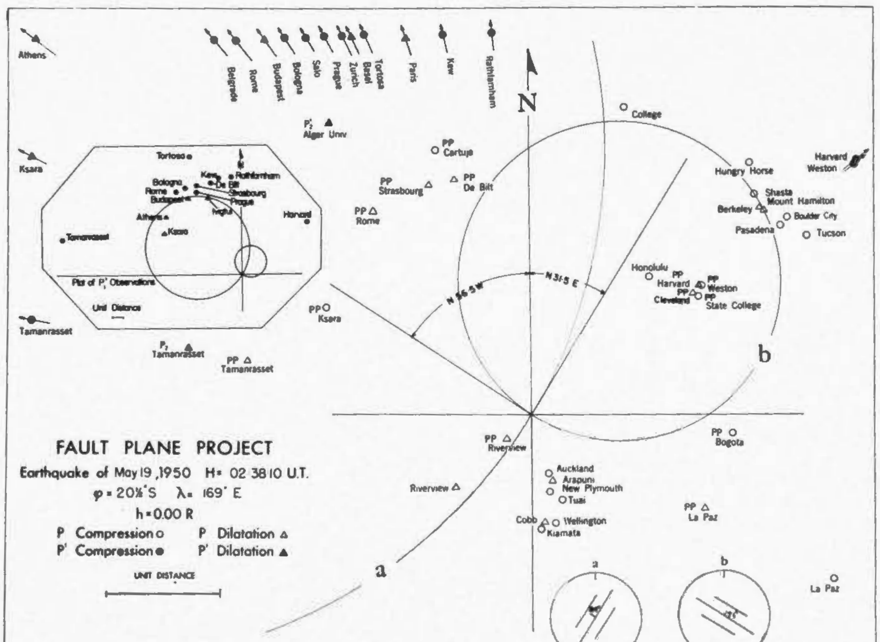


FIGURE 2.

The second circle, drawn in accordance with the orthogonality criterion, separates the dilatations recorded at Berkeley and at Mount Hamilton from the compressions general in the rest of North America. This circle, as drawn, makes Honolulu inconsistent, but the observation at this station is described as "poor". The circle also contains four PP observations, two of them consistent and two inconsistent. The PP dilatations might have been separated from the compressions by a circle smaller than that drawn, but this would have been at the expense of the observations at Berkeley and Mount Hamilton, described as "good" by our collaborators.

A more serious interpretational difficulty arose in New Zealand, where most of the observations were described as doubtful. The preponderance of evidence suggests that all of New Zealand received an initial compression. If this is not true, then the large circle (designated *a* in the figure) would have to be swung around to include the New Zealand stations; this would destroy the separation accomplished in the P′ observations. On the whole, the present solution seems to be the most satisfactory. The observations are summarized in Table V.

The insert diagrams illustrate the geology of the situation. We have to choose between a plane striking N 31°.5 E and dipping 84° to the northwest, and a plane striking N 56°.5 W and dipping 71° to the northeast. In either case the faulting is strongly transcurrent with a very small thrust component.

Earthquake of 07:05:31, May 19, 1950. $\phi = 20\frac{1}{2}$°S, $\lambda = 169$°E

This earthquake is an aftershock of that just discussed, and the solution, shown in Figure 3, is much the same as for the main shock. There are fewer observations of P′ with which to define the position of the larger circle. It has been drawn in a mean position

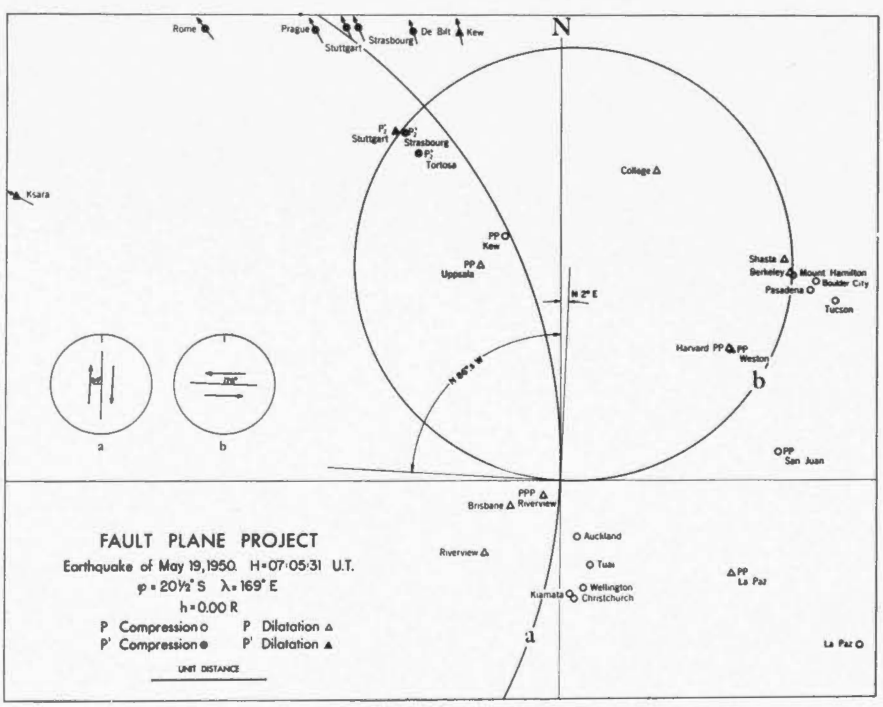


FIGURE 3.

from which a variation of $\pm 1°$ would be permitted by the data. The second circle is very well defined by a separation between Berkeley and Mount Hamilton. It is interesting to note also that this small circle provides a separation between the P_2' observations at Strasbourg and Stuttgart, which have a different direction of movement.

It will be recalled that in the previous example there was some difficulty in deciding whether New Zealand should be plotted as a compressional or dilatational area. In this case there is no ambiguity, all the New Zealand P observations being clearly compressional. This suggests that the correct decision was made in the previous example, where New Zealand was taken to be compressional.

TABLE VI

	P	P_1'	P_2'	PP	PPP	Total
Total Number of Observations............	15	7	3	8	1	34
Number of Inconsistent Observations......	0	1	0	3	0	4

The distribution of inconsistent observations among the several phases recorded is shown in Table VI. None of the inconsistencies is serious. The insert diagrams in Figure 3 illustrate the two geological possibilities, which do not differ very much from those in the main shock.

Earthquake of 01:17:25, May 26, 1950. $\phi = 20\frac{1}{4}°S$, $\lambda = 169\frac{1}{4}°E$

As is shown in Table VII, while the number of inconsistencies in the other phase is reasonably small, there are 9 inconsistent observations out of 31 observations of P_1'. This number seems very large. Most of the discrepant observations are not, however, too serious, since they lie surrounded by consistent observations. One exception to this is provided by the group of stations in northeastern United States. Harvard, Weston and

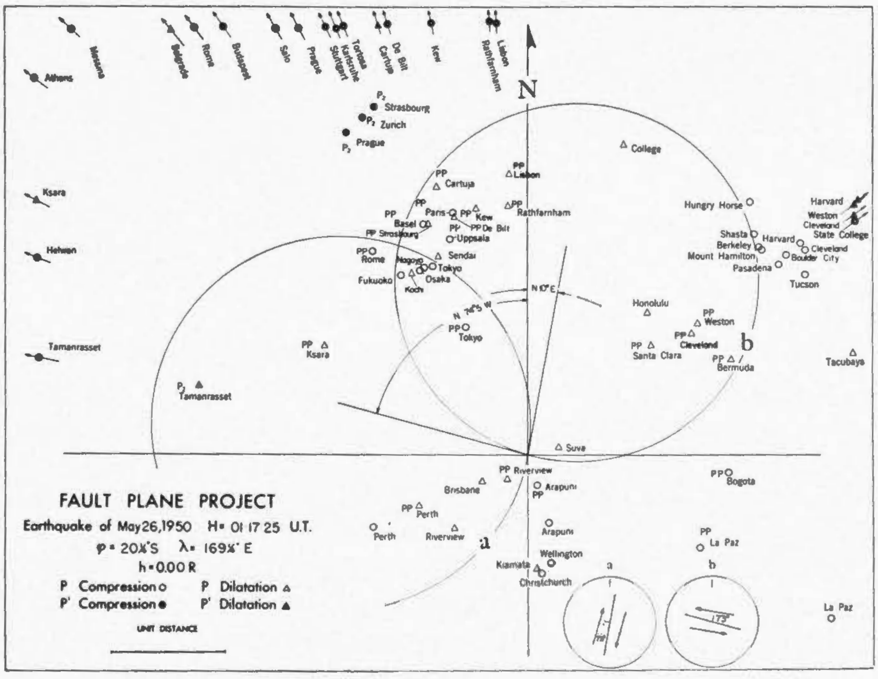


FIGURE 4.

Cleveland all report "clear" dilatations. It has not proved possible to bring these observations into a solution that makes the P compressions, well observed in California, also consistent. It is necessary to conclude that the P′ observations are inconsistent, and these constitute a serious criticism of the solution.

TABLE VII

	P	P_1'	P_2'	PP	pP	Total
Total Number of Observations.	27	31	4	22	1	85
Number of Inconsistent Observations.	4	9	0	4	1	18

As shown in the insert diagrams of Figure 4, the solution again shows transcurrent faulting, with a weak thrust component.

Earthquake of 12:39:43, May 27, 1950. $\phi = 20°S$, $\lambda = 168°E$

This earthquake, which had a focal depth of 200 km., was a little too small to provide a satisfactory solution. As shown in Table VIII, there were not as many observations reported as usual, and there is a higher percentage of inconsistencies. Most of these inconsistencies come from P_1' observations at distant stations, and undoubtedly reflect the low magnitude of the earthquake. In spite of the difficulties it seems worthwhile to publish the solution, as shown in Figure 5, since no radically different solution seems possible. Note the reduced scale of the figure as compared with earlier diagrams. This enables the observations of P′ to be plotted on scale. The insert diagrams to the figure indicate that the faulting is almost purely transcurrent.

TABLE VIII

	P	P_1'	P_2'	PP	Total
Total Number of Observations.	15	16	1	3	35
Number of Inconsistent Observations.	2	7	0	0	9

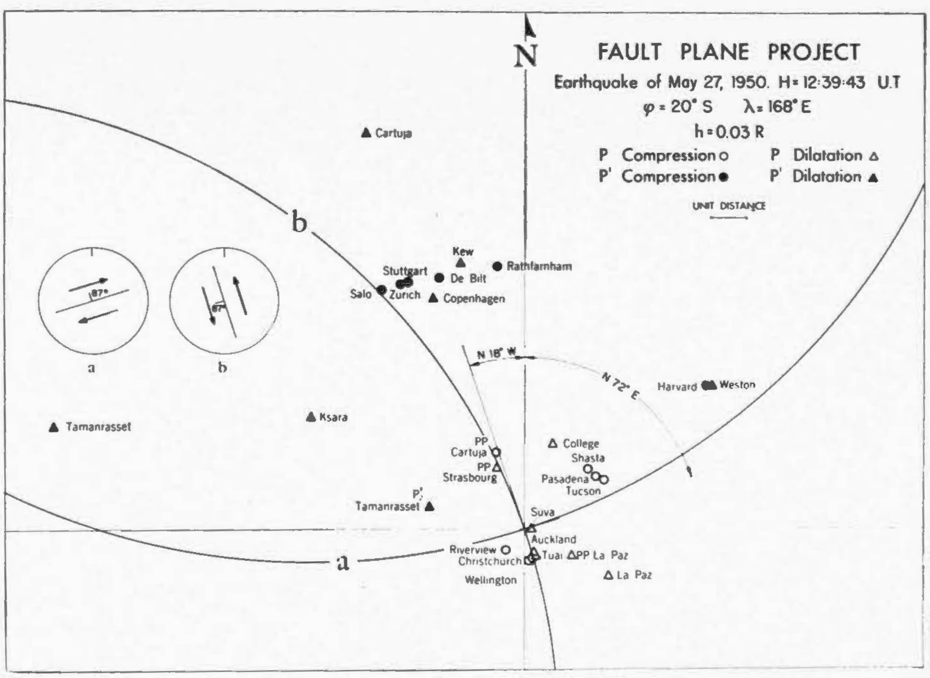


FIGURE 5.

Earthquake of 01:36:44, May 28, 1950. $\phi = 20°S$, $\lambda = 169°E$

The solution for this earthquake, shown in Figure 6, scores 10 failures out of 44 observations. These are enumerated in Table IX. Almost all the inconsistent observations have been described by the readers as doubtful. One exception is that for Berkeley, which is inconsistent with "good" observations at Shasta and Mount Hamilton, but which is itself described as a "fair" observation.

TABLE IX

	P	P_1'	P_2'	PP	Total
Total Number of Observations..................	15	17	2	10	44
Number of Inconsistent Observations............	3	4	0	3	10

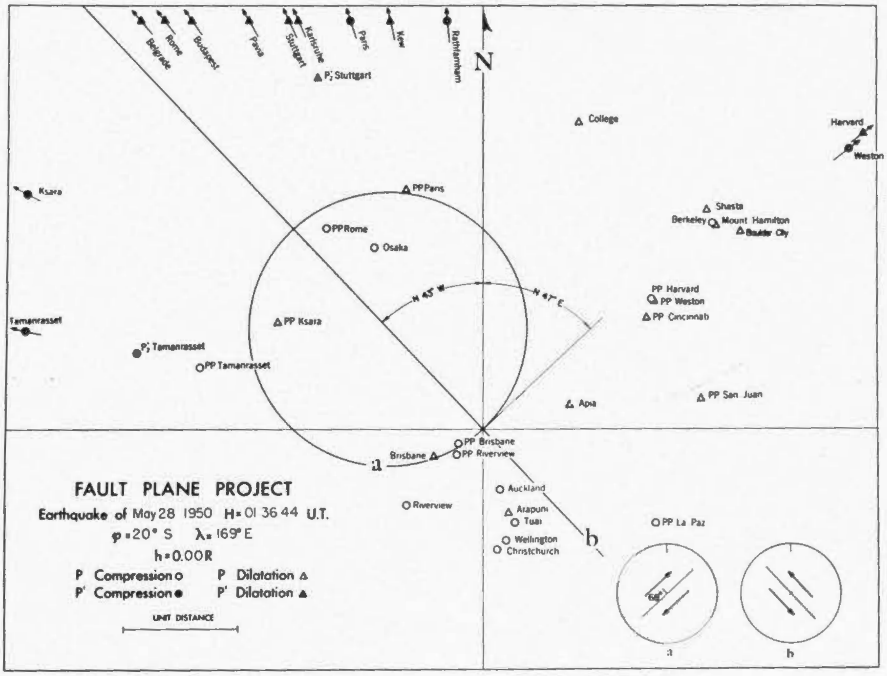


FIGURE 6.

The solution shown in Figure 6, has one plane vertical. In fact the data do not insist on absolute verticality for this plane; a slight curvature in either direction could be tolerated. The solution, as drawn, represents an average position.

Since the one plane has been drawn vertical, the insert diagrams show the faulting to be purely transcurrent.

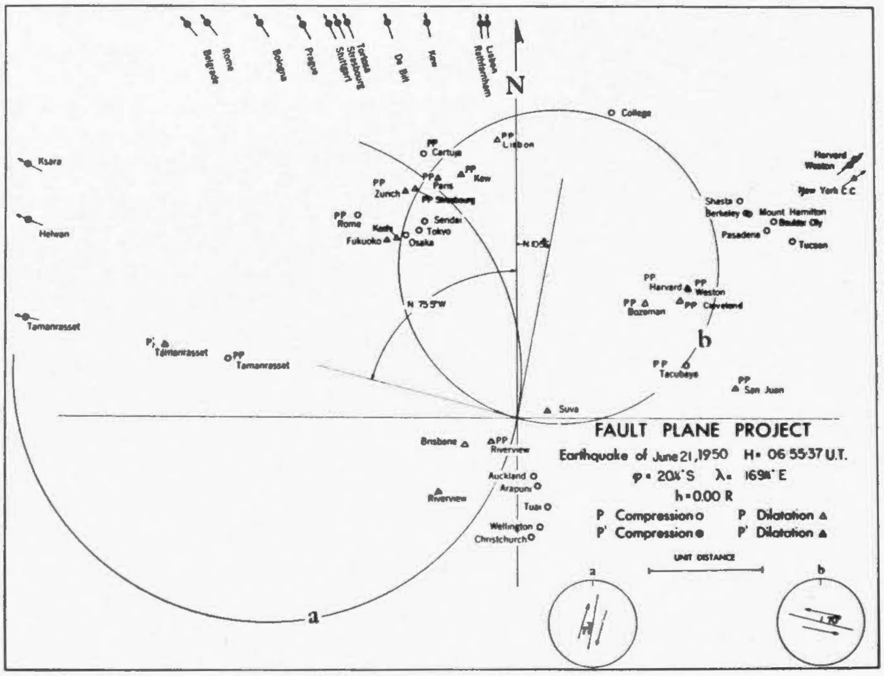
Earthquake of 06:55:37, June 21, 1950. $\phi = 20\frac{1}{4}°S$, $\lambda = 169\frac{1}{4}°E$

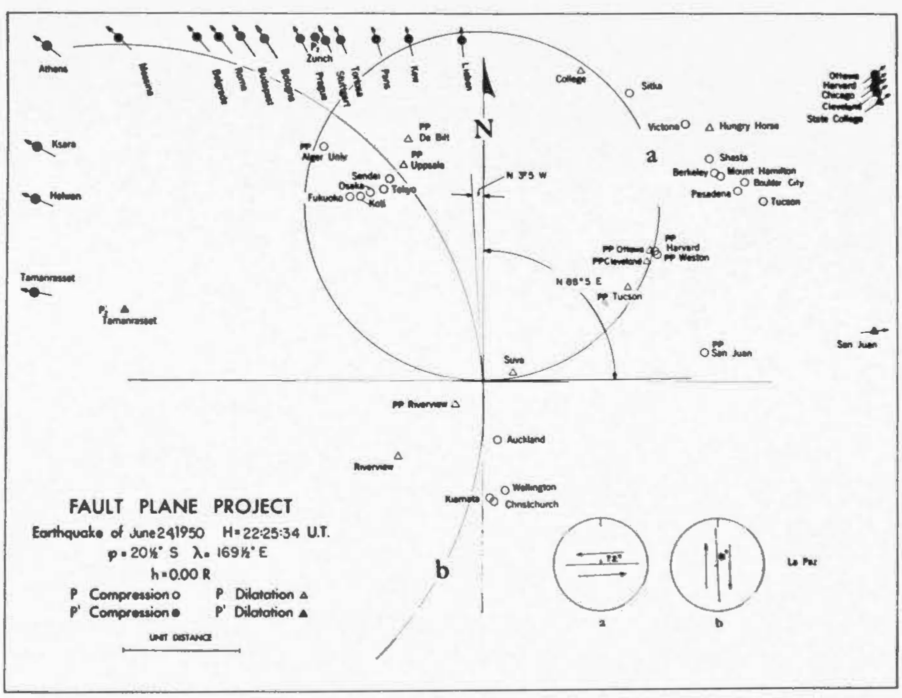
The solution for this earthquake, shown in Figure 7, assumes that the circles are dilatational and that the field should therefore be compressional. As shown in Table X, all but 6 of the 26 observations of P_1' support this, and the inconsistencies are scattered in azimuth. The score on the other phases is reasonably satisfactory.

TABLE X

	P	P_1'	P_2'	PP	Total
Total Number of Observations..................	25	26	1	15	67
Number of Inconsistent Observations............	5	6	0	4	15

The insert diagrams show that the faulting is largely transcurrent; since the circles contain dilatations, the minor component is a thrust.





FIGURES 7 and 8.

Earthquake of 22:25:34, June 24, 1950. $\phi = 20\frac{1}{2}°S$, $\lambda = 169\frac{1}{2}°E$

The total number of observations, and the number of these inconsistent with the solution here presented, is given in Table XI. The solution itself, which is presented in Figure 8, is quite straightforward and requires no explanation.

TABLE XI

	P	P_1'	P_2'	PP	Total
Total Number of Observations	25	33	2	19	79
Number of Inconsistent Observations	4	7	0	6	17

Earthquake of 20:17:50, July 17, 1950. $\phi = 20\frac{1}{2}°S$, $\lambda = 171°E$

The solution of this earthquake, shown in Figure 9, consists of two planes so steeply dipping that it has been necessary to plot the map on a reduced scale. As itemized in Table XII, the solution accounts for a total of 42 observations with 8 inconsistencies, none of which is serious.

TABLE XII

	P	P_1'	P_2'	PP	pP	Total
Total Number of Observations	20	15	1	5	1	42
Number of Inconsistent Observations	4	3	0	1	0	8

As shown in the insert diagrams, faulting is transcurrent with a slight thrust component.

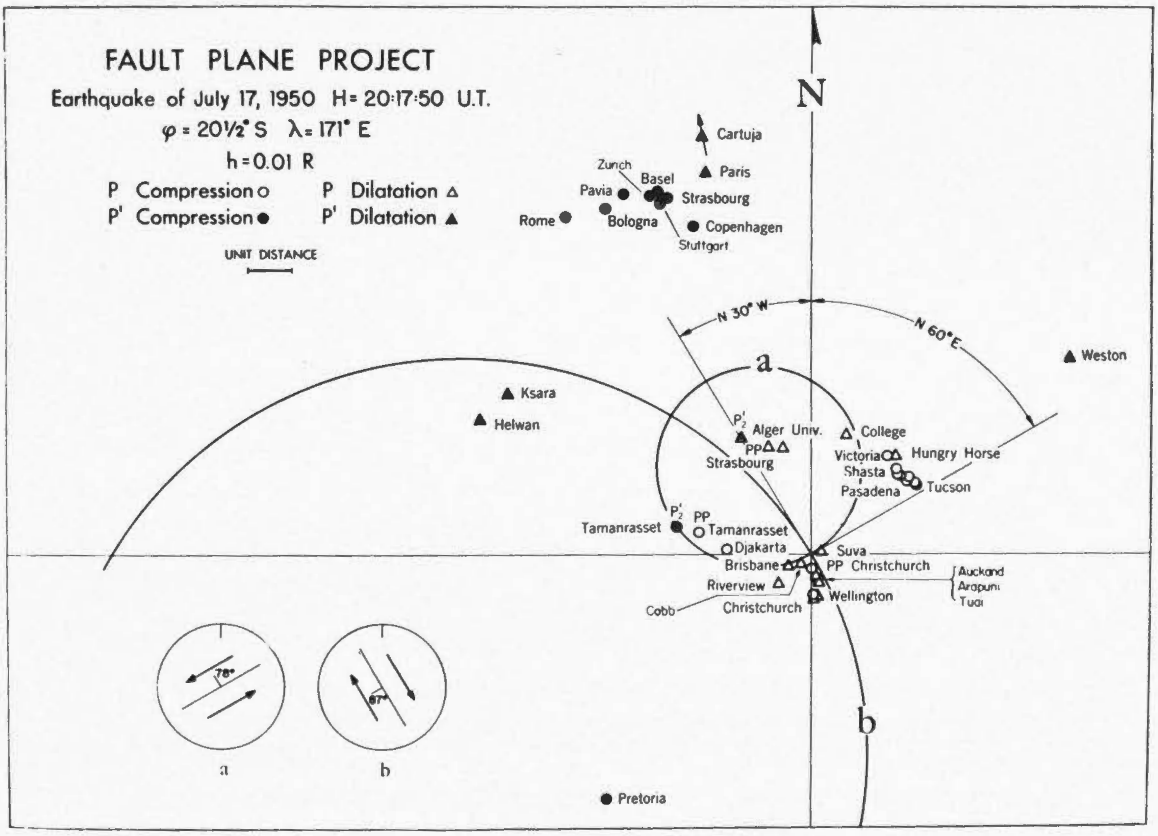


FIGURE 9.

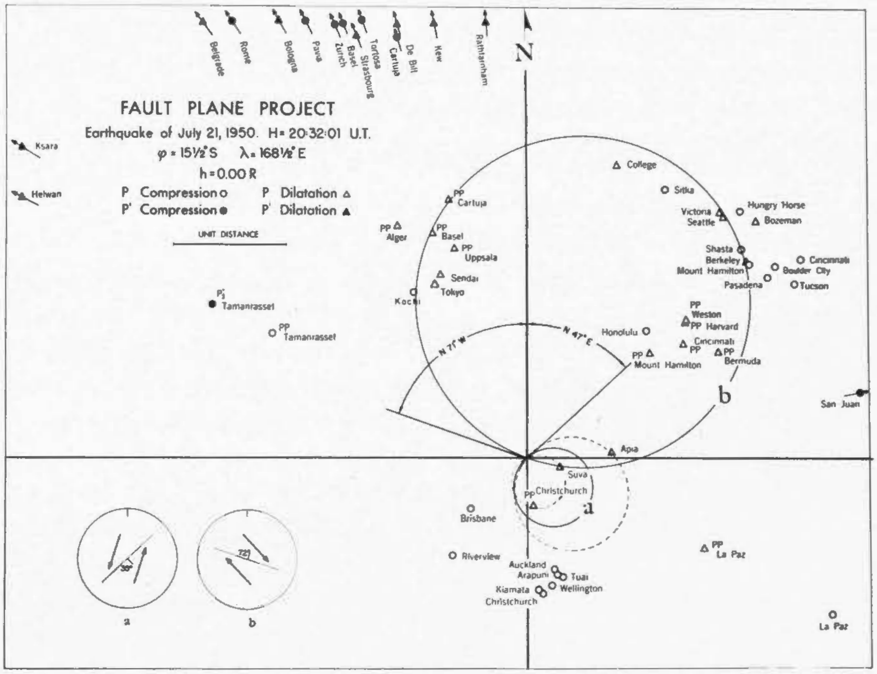


FIGURE 10

Earthquake of 20:32:01, July 21, 1950. $\phi = 15\frac{1}{2}°S, \lambda = 168\frac{1}{2}°E$

So many of the earthquakes analysed in the fault-plane project to date have shown nearly pure transcurrent faulting that any evidence in favour of non-transcurrent faulting should be submitted to the reader, even though that evidence is not clear. The solution for this earthquake, shown in Figure 10, is published with this thought in mind; the reader is cautioned to examine it critically.

It will be noted in the figure that a separation is clearly indicated in Japan (Kochi and Tokyo move in opposite senses) and also along the Pacific shore of North America. These separations have been made with circle *b*. A second circle can be drawn to bring in Suva and the PP observation of Christchurch and to satisfy the orthogonality criterion. The extreme and mean positions of this circle *a* have been indicated. The score for this solution is indicated in Table XIII. For the phases other than P_1' the score is not too bad, particularly since many of the inconsistencies are not serious. For example the Berkeley observation is described as "questionable" and in any event Berkeley is very close to the circle as drawn. Observations at Bozeman, Honolulu, Cobb, New Plymouth are also described as questionable.

TABLE XIII

	P	P_1'	P_2'	PP	pP	Total
Total Number of Observations............	30	18	1	17	1	67
Number of Inconsistent Observations......	6	8	0	5	1	20

It is when one turns to the observations of P_1' that doubts arise. Here 8 out of 18 observations show dilatations instead of the compressions demanded by the published solution. Repeated attempts have been made to find a system of circles which would effect a separation of compressions and dilatations in the P_1' and still satisfy the separations in Japan and California. No such system has been found and it has been necessary to conclude that all P_1' observations should be compressional. There is some justification for this in that at least four stations reported a small initial compression followed by a much larger dilatation. Perhaps the inconsistent stations failed to record the small initial compression.

The insert diagrams are based on the mean position of circle *a*. Even in this case the thrust component is very large. Had the smallest value of circle *a* been plotted the thrust nature of the faulting would have been still more pronounced. It will bear repeating that this solution is being published, despite the doubts which attend it, because it does suggest the possibility of a large dip component of motion.

Earthquake of 23:08:00, July 22, 1950. $\phi = 14°S$, $\lambda = 167°E$

This earthquake was rather small, and was not widely recorded, but, as shown in Table XIV, the percentage of inconsistencies is about normal. The solution is shown in Figure 11. It should be noted that this figure is drawn to a reduced scale because of the large size of circle *b*. The insert diagrams demonstrate that the faulting is again transcurrent, with a very small thrust component.

TABLE XIV

	P	P_1'	P_2'	PP	Total
Total Number of Observations..................	10	11	2	4	27
Number of Inconsistent Observations............	2	3	0	2	7

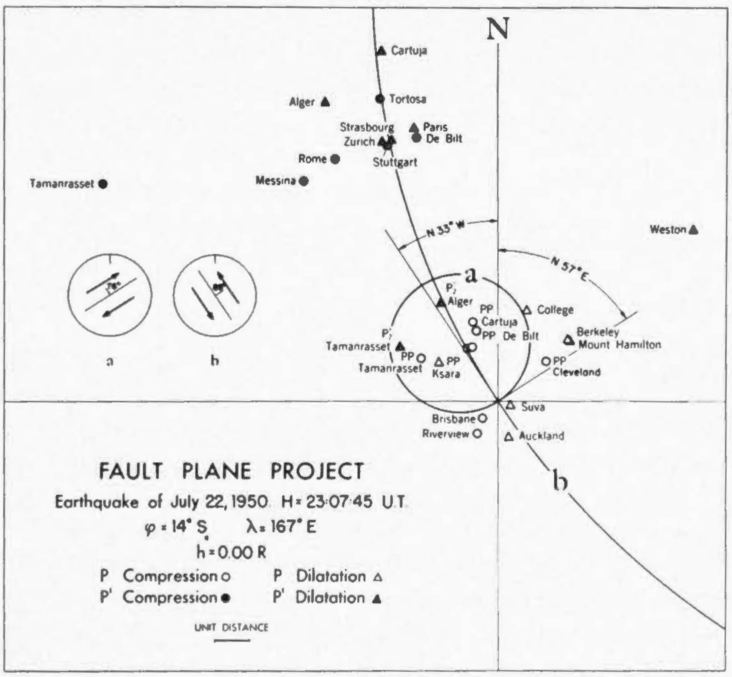


FIGURE 11

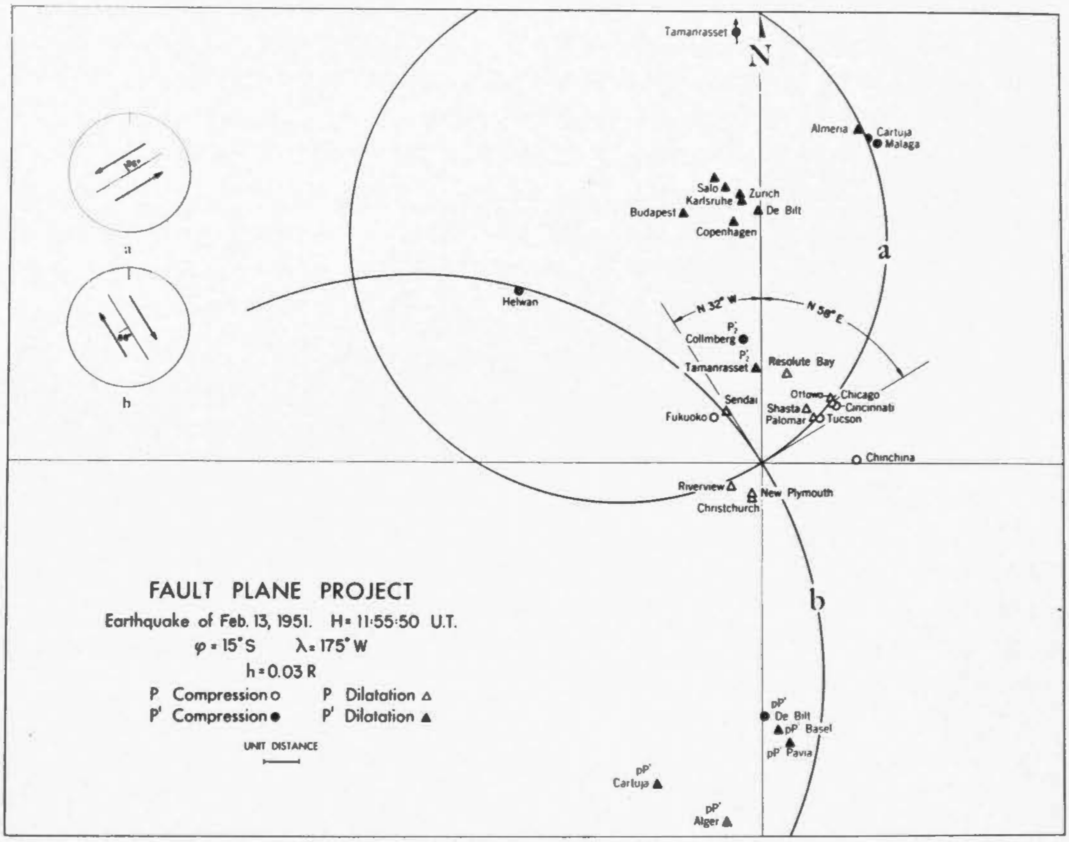


FIGURE 12

Earthquake of 11:55:50, Feb. 13, 1951. $\phi = 15°S$, $\lambda = 175°W$

This earthquake was very widely recorded, a total of 74 observations being available. The solution shown in Figure 12 accounts for all but 16 of these observations.

This solution marks the first time that the phase pP_1' has been used to any large extent in plotting. In order not to confuse the diagram only a few of these observations have been plotted on the figure.

TABLE XV

	P	P_1'	P_2'	PP	pP	pP_1'	Total
Total Number of Observations............	32	21	3	6	2	10	74
Number of Inconsistent Observations......	6	1	2	2	1	4	16

The insert diagrams illustrate that the faulting is almost purely transcurrent on almost vertical planes.

Earthquake of 21:38:54, March 23, 1951. $\phi = 31°S$, $\lambda = 180°$

The solution for this earthquake, shown in Figure 13, has 21 inconsistencies among 78 observations. Three of the P inconsistencies are for California stations and lie well surrounded by consistent observations. Two other P inconsistencies are from Suva and Tuai which lie so close to the epicentre that slight error in focal depth, epicentre or in our tables of extended distances could account for the errors.

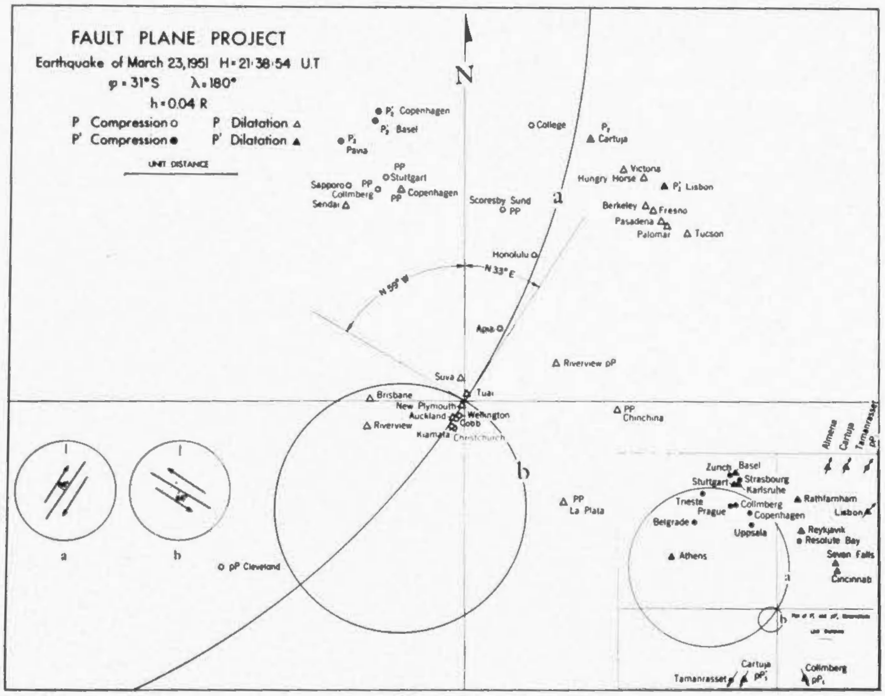


FIGURE 13

TABLE XVI

	P	P_1'	P_2'	PP	pP	pP_1'	Total
Total Number of Observations............	31	23	8	11	2	3	78
Number of Inconsistent Observations......	6	6	2	6	0	1	21

None of the inconsistencies in P_1' is particularly serious. The circle *a* might have been drawn larger to include Resolute Bay, Strasbourg and Zurich, but this would have been at the expense of Stuttgart and Karlsruhe. Geologically the difference is slight, an increase of about 1° in the dip of the plane.

The insert diagrams illustrate the two geological possibilities. The uncertainty in the dip of plane *b* is $\pm 5°$, since the circle *b* is not closely limited bv the data.

Earthquake of 16:31:11, August 28, 1951. $\phi = 27°S$, $\lambda = 178°E$

The solution for this earthquake is shown in Figure 14 and the data on which it is based are summarized in Table XVII. Of the four inconsistent observations of P, two are from stations (Auckland and New Plymouth) so near to the epicentre that slight error in epicentre or focal depth could account for them, while a third is for Pierce Ferry, which lies in a cluster of consistent readings. The two inconsistent observations (Butte and College) of pP have been shown in the figure. Both readings are described as doubtful.

TABLE XVII

	P	P_1'	P_2'	PP	pP	pP_1'	Total
Total Number of Observations............	22	9	4	2	6	2	45
Number of Inconsistent Observations......	4	2	2	0	2	0	10

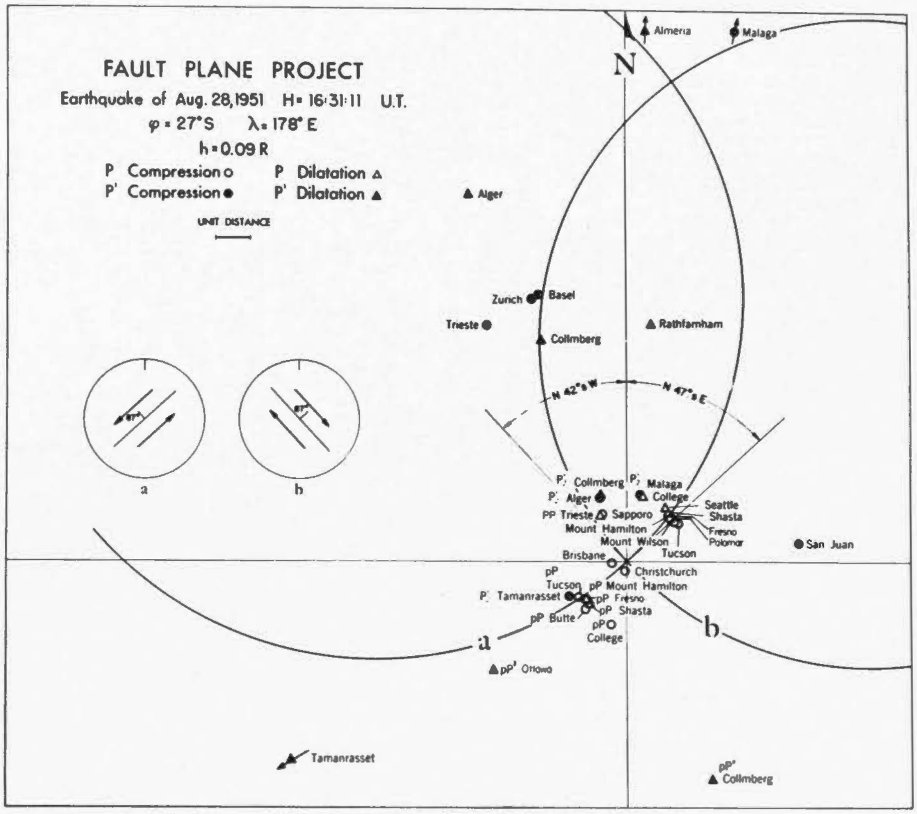


FIGURE 14

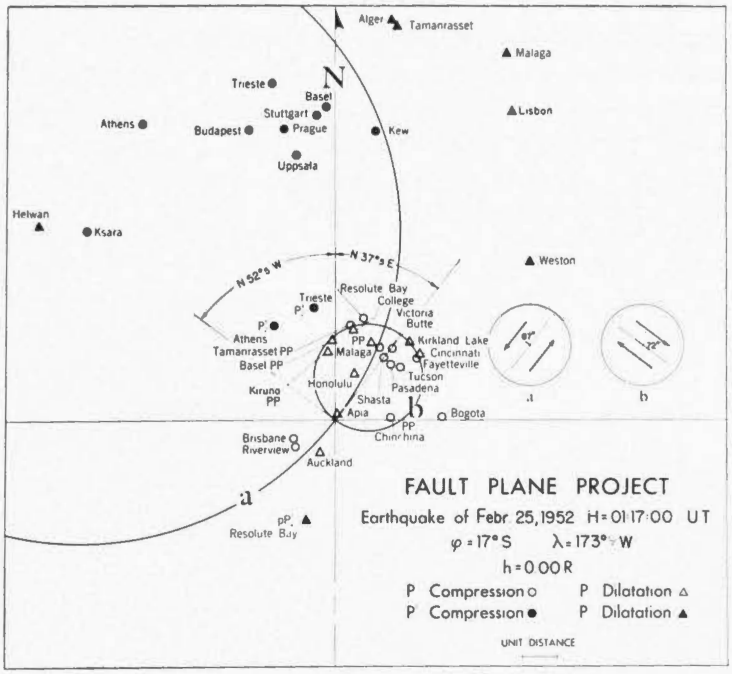
This earthquake had a focal depth of 0·09R, one of the deepest for which a fault-plane solution has been obtained. As shown in the insert diagrams to Figure 14 the faulting is almost purely transcurrent, on almost vertical planes. In an earlier paper[3] a solution for a normal focus earthquake from the same area (the Kermadecs) was given. The two solutions are almost identical except that, whereas the normal-focus earthquake was solved with dilatational circles, the present deep-focus earthquake requires compressional circles.

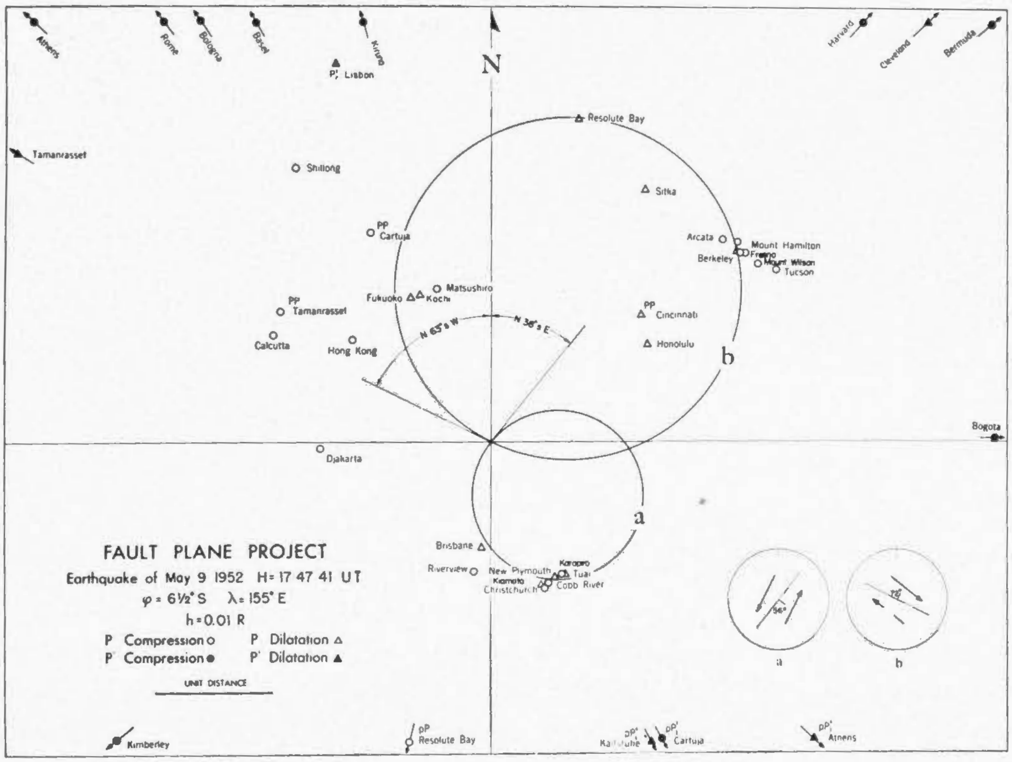
Earthquake of 01:17:00, Feb. 25, 1952. $\phi = 17°S$, $\lambda = 173\frac{1}{2}°W$

The solution of this earthquake is shown in Figure 15, while the data on which it is based are summarized in Table XVIII. One group of inconsistencies is worthy of discussion. Three of the New Zealand stations showed compressions, three dilatations, but the stations were not aligned in such a way that the two groups could be separated. Only one station, Auckland, has been shown on the diagram, and the solution assumes the entire New Zealand area to be dilatational.

TABLE XVIII

	P	P_1'	P_2'	PP	pP_1'	Total
Total Number of Observations............	32	24	5	11	3	75
Number of Inconsistent Observations......	5	4	3	3	1	16





FIGURES 15 and 16

Earthquake of 17:47:41, May 9, 1952. $\phi = 6\frac{1}{2}°S, \lambda = 155°E$

The solution for this earthquake is shown in Figure 16, while the data on which it is based are summarized in Table XIX. There are some anomalies in the solution which are worthy of discussion. Circle *a*, as drawn, makes Christchurch and Cobb correct, Brisbane and Kiamata wrong. If the radius had been increased this could have been reversed, Brisbane and Kiamata becoming consistent at the expense of Christchurch and Cobb. By a complete reorientation of the circle all of these stations might have been made consistent, but the orthogonality criterion would then have demanded an inconsistent position for circle *b*. The solution given in the figure is the best compromise, and is probably not very far from the truth.

TABLE XIX

	P	P_1'	P_2'	PP	pP	pP_1'	Total
Total Number of Observations............	29	29	1	6	1	4	70
Number of Inconsistent Observations......	5	7	1	1	0	3	17

It should be noted that this is the first solution obtained for an earthquake in the Soloman Islands.

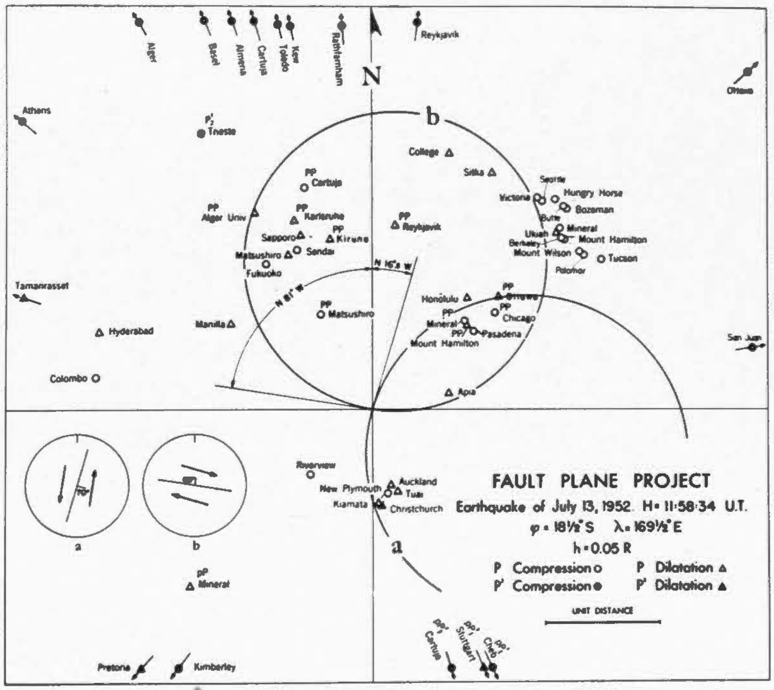


FIGURE 17

Earthquake of 11:58:34, July 13, 1952. $\phi=18\frac{1}{2}°S$, $\lambda=169\frac{1}{2}°E$

The solution for this earthquake is shown in Figure 17, while the data on which it is based are shown in Table XX.

TABLE XX

	P	P_1'	P_2'	PP	pP	pP_1'	Total
Total Number of Observations............	40	28	1	18	2	3	92
Number of Inconsistent Observations......	8	9	0	4	1	1	23

The positions of the circles as drawn in the figure may not be entirely correct. By shortening up the radius of circle *b*, Apia, Fukuoko and the PP observation at Cartuja could be made consistent, but only at the expense of College and Sitka. On the other hand, increasing the radius of circle *b* would make Ukia and Santa Clara consistent, but at the additional expense of Victoria and Seattle. Circle *b* is therefore drawn in a mean position, and none of the inconsistencies mentioned is too serious.

Earthquake of 08:23:22, July 27, 1952. $\phi=20\frac{1}{2}°S$, $\lambda=179°W$

The data on which Figure 18 is based are summarized in Table XXI, which also shows the number of inconsistent observations. Some of these inconsistencies are disturbing. In particular, the inconsistencies in P_2' at Prague, and in P_1' at Prague, Chur, Stuttgart and Alger lie grouped about the same azimuth in such a way as to suggest that they must be brought into the solution. No way has been found to do this without making many other stations inconsistent, but the reader should bear in mind this group of observations in appraising the value of the solution.

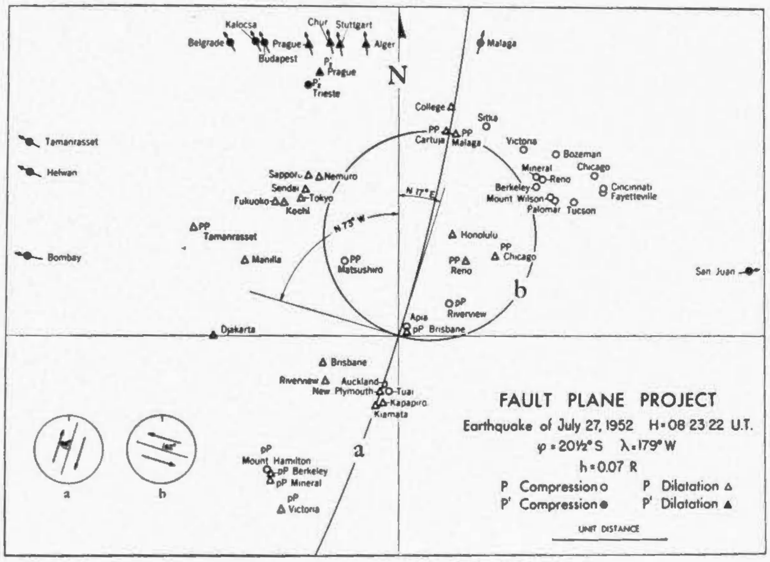


FIGURE 18

TABLE XXI

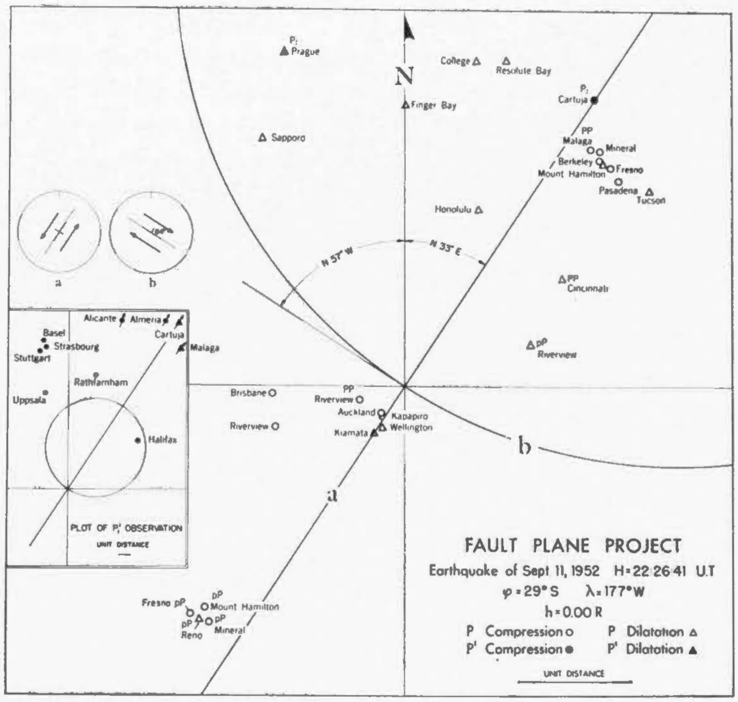
	P	P_1'	P_2'	PP	pP	pP_1'	Total
Total Number of Observations............	35	20	2	11	5	1	74
Number of Inconsistent Observations......	4	5	1	4	2	1	17

Earthquake of 22:26:41, Sept. 11, 1952. $\phi=29°S$, $\lambda=177°W$

This earthquake provided a smaller body of data than most of the other considered, but the percentage of inconsistencies is about normal. The solution in terms of one vertical plane seems to be demanded both by the distribution in New Zealand and by the fact that the P_1' and the P_2' observations for Cartuja are in opposite senses. The number of inconsistencies, as shown in Table XXII, is about normal.

TABLE XXII

	P	P_1'	P_2'	PP	pP	Total
Total Number of Observations............	19	14	3	3	5	44
Number of Inconsistent Observations......	2	2	1	1	2	8



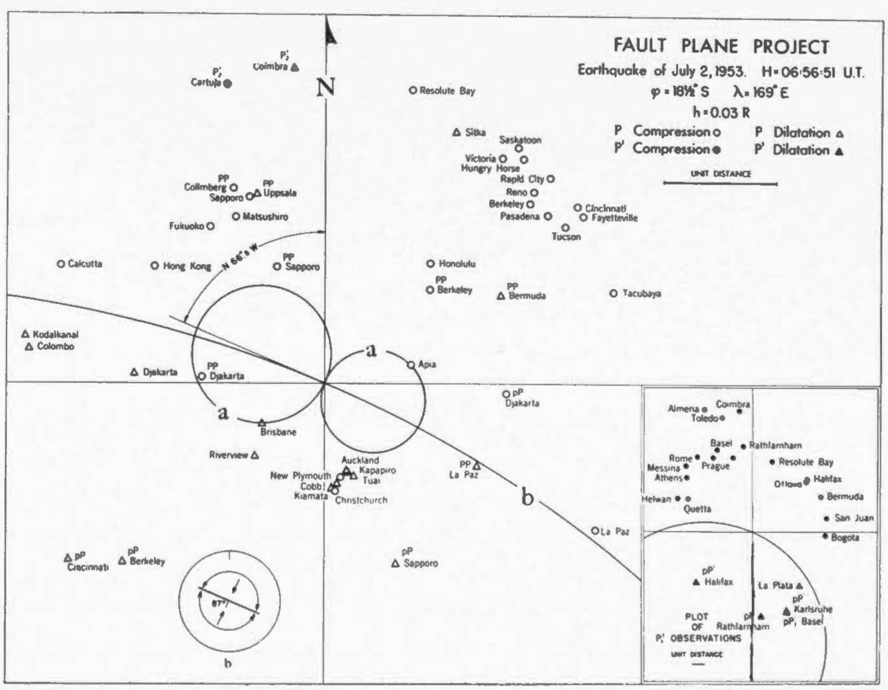


FIGURE 19 and 20.

Earthquake of 06:56:51, July 2, 1953. $\phi = 18\frac{1}{2}°S$, $\lambda = 169°E$

The solution for this earthquake, shown in Figure 20, is not closely defined, since any circle lying between a' and a'' would satisfy the data satisfactorily. The inconsistencies shown in Table XXIII are based on circle a', but a single observation of PP is not a sufficient basis for insisting on the circle a' and so throwing out the possibility of purely thrust faulting.

TABLE XXIII

	P	P_1'	P_2'	PP	pP	pP_1'	pP_2'	Total
Total Number of Observations........	54	37	3	15	8	8	1	126
Number of Inconsistent Observations..	5	5	2	3	1	2	0	18

The insert diagram supposes that plane b represents the fault, and indicates that the motion may lie anywhere between transcurrent in either sense to pure thrust.

Earthquake of 00:26:36, Sept. 14, 1953. $\phi = 18\frac{1}{2}°S$, $\lambda = 178\frac{1}{2}°E$

This is the first earthquake which we have considered in the vicinity of the Fiji Islands, and it seems worthwhile to publish the tentative solution shown in Figure 21 even though the number of inconsistencies is higher than normal, for it is clear that the solution must be at least approximately correct.

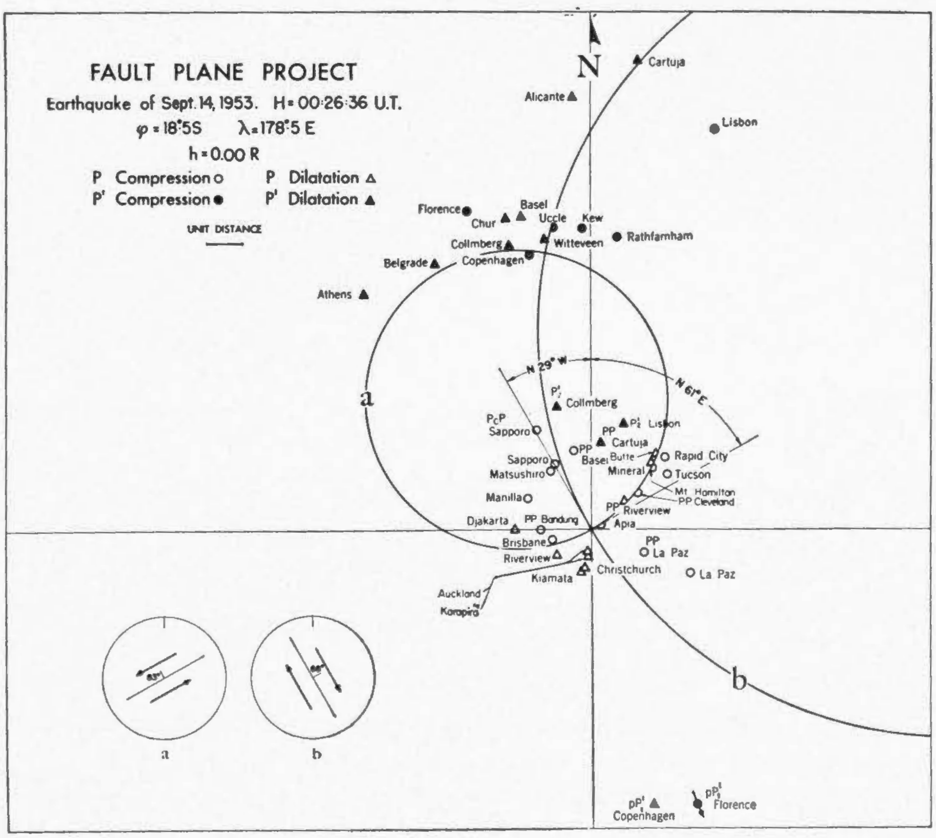


FIGURE 21

Of the inconsistent observations of P, two are in New Zealand and derive from EW seismographs. Since the stations are almost south of the epicentre the error is not surprising. Three other inconsistencies come from California stations lying very close to circle *a*.

TABLE XXIV

	P	P_1'	P_2'	PP	pP	pP_1'	PcP	Total
Total Number of Observations........	33	21	3	10	1	3	1	72
Number of Inconsistent Observations..	8	4	1	7	0	2	0	22

The most serious group of inconsistencies is provided by the PP phase. Five of the recorded inconsistencies derive from stations lying between Basel and Cartuja in the overlap zone of the two circles. Most of these inconsistent observations are described by the readers as "doubtful", but the solid group does constitute a criticism of the solution.

Earthquake of 01:36:45, Sept. 29, 1953. $\phi = 36\frac{1}{2}°S$, $\lambda = 177°E$

The largest group of inconsistencies in this solution are provided by the phase P_1'. This is not surprising considering the location of the epicentre. Most of the Spanish stations, for example, are almost 180° distant from the epicentre. A more serious series of inconsistencies are provided by the normally consistent group of stations Djakarta, Hong Kong, Hyderabad, Bombay and Athens, a group of compressions all lying along the same azimuth. There does not seem to be any explanation for this group.

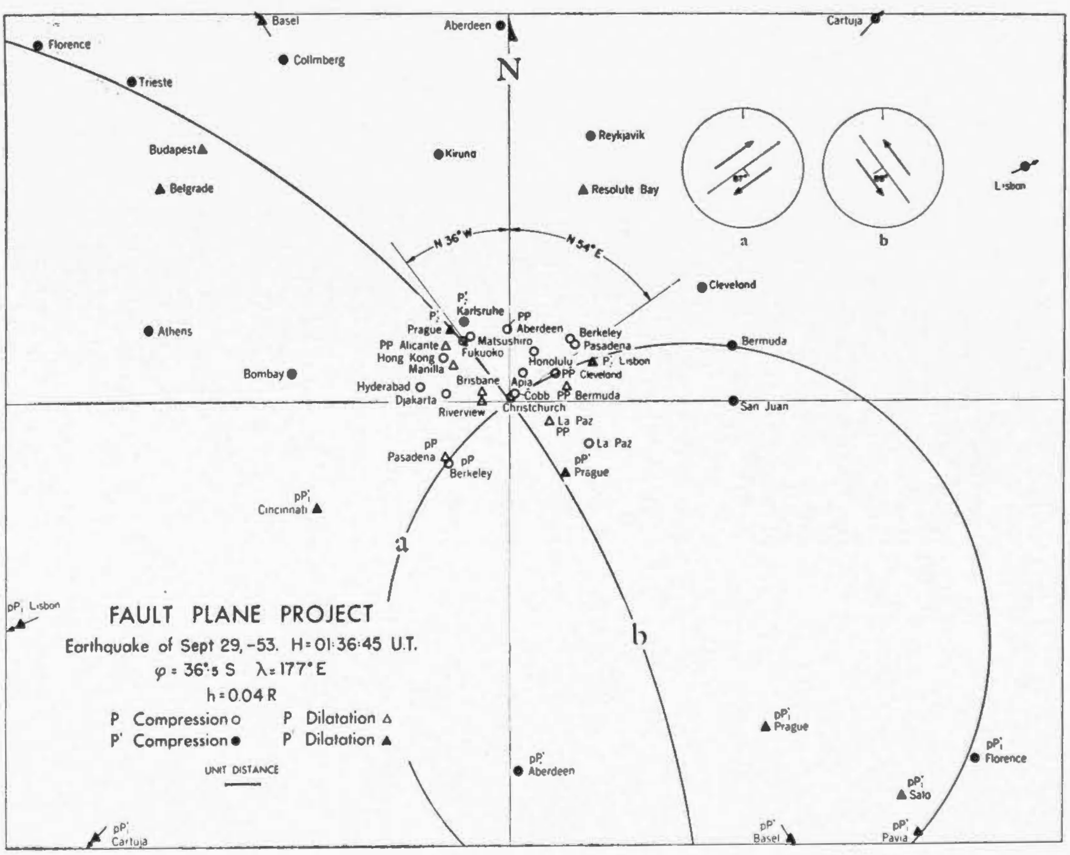


FIGURE 22

TABLE XXV

	P	P_1'	P_2'	PP	pP	pP_1'	pP_2'	Total
Total Number of Observations........	33	30	6	15	5	13	3	105
Number of Inconsistent Observations..	6	11	3	2	1	2	2	27

Earthquake of 00:13:06, Jan. 13, 1954. $\phi = 49°S$, $\lambda = 165°E$

This, the final earthquake of the present series, is the most southerly epicentre yet considered. It will be seen that, once again, transcurrent faulting along an almost vertical plane is indicated.

TABLE XXVI

	P	P_1'	P_2'	PP	PcP	pP	Total
Total Number of Observations............	16	12	7	16	2	2	55
Number of Inconsistent Observations......	1	1	0	4	0	1	7

The score on this earthquake, as shown in Table XXVI, is remarkably good. The only serious discrepancy is for Riverview, both P and pP. It should be noted that a slight shift in the epicentre could have brought both these observations into consistency.

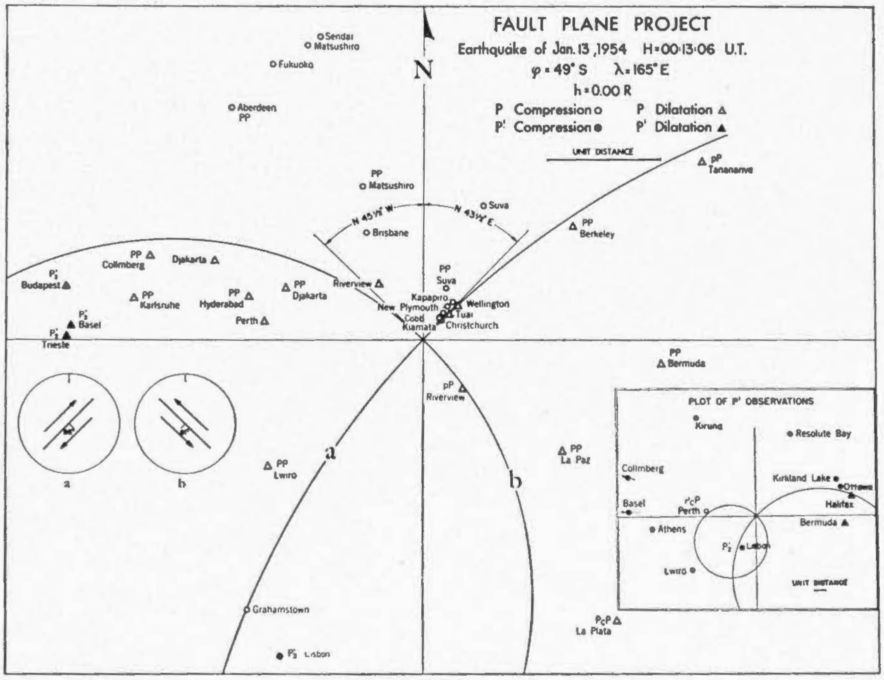


FIGURE 23

SUMMARY AND DISCUSSION

PRESENTATION OF THE DATA

Table XXVII summarizes the results of all fault-plane solutions available for southwest Pacific earthquakes. This includes the data obtained by Webb[10] for five earthquakes and by Hodgson and Storey[3] for two others. The remaining results tabulated are from the present paper.

TABLE XXVII

Summary of Fault-Plane Solutions Available for Southwest Pacific Earthquakes

Earthquake					Plane a					Plane b				
No.	Date	φ	λ	h	Strike Direction	Dip Direction	Dip	Strike Component	Dip Component	Strike Direction	Dip Direction	Dip	Strike Component	Dip Component
										–				
	Solomon Islands													
1	May 9, 1952	6½°S	155°E	0·01R	N38°5E	S51°5E	56°	0·928	+0·373	N63°5W	N26·5E	72°	0·809	+0·588
	New Hebrides Islands													
2	July 22, 1950	14°S	167°E	0·00R	N57°E	N33°W	76°	1·000	+0·018	N33°W	N57°E	89°	0·970	+0·242
3*	Mar. 10, 1951	15¼°S	167½°E	0·02R	N41°E	N49°W	84°	0·988	−0·157	N48°W	N42°E	81°	0·994	−0·105
4	July 21, 1950	15½°S	168½°E	0·00R	N47°E	S43°E	35°	0·842	+0·539	N71°W	N19°E	72°	0·508	+0·861
5*	Dec. 2, 1950	18¼°S	167°E	0·00R	N45°E	S45°E	86°	0·999	+0·034	N44°W	S46°W	88°	0·998	+0·069
6†	July 23, 1949	18½°S	169°E	0·03R	N49°E	S41°E	67°	0·995	+0·095	N40°W	S50°W	85°	0·919	+0·393
7	July 13, 1952	18½°S	169½°E	0·05R	N16°5E	S73°5E	70°	0·924	+0·381	N81°W	N9°E	69°	0·930	+0·367
8	July 2, 1953	18½°S	169°E	0·03R	——	——	——	+	+	N66°5W	S23°5W	——	——	+
9	May 27, 1950	20°S	168°E	0·03R	N72°E	N18°W	87°	0·999	−0·054	N18°W	S72°W	87°	0·999	−0·051
10	May 28, 1950	20°S	169°E	0·00R	N47°E	N43°W	68°	1·000	0·000	N43W	——	90°	·927	0·375
11	May 26, 1950	20¼°S	169¼°E	0·00R	N10°E	N80°W	73°	0·952	+0·306	N74°5W	N15°5E	73°	0·952	+0·306
12	June 21, 1950	20¼°S	169¼°E	0·00R	N10°5E	N79°5W	77°	0·936	+0·351	N75°5W	N14°5E	70°	0·971	+0·239
13	May 19A, 1950	20½°S	169°E	0·00R	N31°5E	N58°5W	84°	0·944	+0·329	N56°5W	N33°5E	71°	0·994	+0·111
14	May 19B, 1950	20½°S	169°E	0·00R	N2°E	N88°W	84°	0·970	+0·243	N86°5W	N3°5E	76°	0·994	+0·108
15	June 24, 1950	20½°S	169½°E	0·00R	N88°5E	N1°5W	72°	0·950	+0·313	N3°5W	S86°5W	81°	0·986	+0·164
16	July 17, 1950	20½°S	171°E	0·01R	N60°E	N30°W	78°	0·999	+0·053	N30°W	S60°W	87°	0·978	+0·208
17	May 17, 1950	21°S	169°E	0·00R	N3°5E	N86°5W	79°	0·944	+0·331	N82°5W	N7°5E	71°	0·979	+0·202
	Fiji Islands													
18	Sept. 14, 1953	18½°S	178½°E	0·00R	N61°E	N29°W	83°	0·999	−0·035	N29°W	N61°E	88°	0·993	−0·122
	Tonga Islands													
19	Feb. 13, 1951	15°S	175°W	0·03R	N58°E	N32°W	86°	0·999	+0·035	N32°W	S58°W	88°	0·998	+0·070
20*	June 29, 1948	16°S	173°W	0·01R	N47°E	N43W	86°	0·996	+0·087	N42°W	N48°E	85°	0·998	+0·070
21	Feb. 25, 1952	17°S	173½°W	0·00R	N37°5E	N52°5W	87°	0·951	−0·309	N52°5W	N37°5E	72°	0·999	−0·052
22*	Aug. 6, 1949	19¼°S	174¾°W	0·01R	N45°E	N45°W	80°	0·903	+0·429	N52°W	S38°W	65°	0·982	+0·192
23	July 27, 1952	20½°S	179°W	0·07R	N17°E	N73°W	88°	0·883	+0·470	N73°W	N17°E	62°	0·999	+0·040
24*	Sept. 8, 1948	21°S	174¼°W	0·00R	N28°E	S62°E	87°	0·743	+0·670	N59°W	S31°E	48°	0·998	+0·070
	Kermadec Islands													
25	Aug. 28, 1951	27°S	178°E	0·09R	N47°5E	N42°5W	87°	0·999	−0·053	N42°5W	N47°5E	87°	0·999	−0·053
26†	Nov. 22, 1949	29°S	178°W	0·00R	N49°5E	N40°5W	86°	0·999	+0·035	N40°5W	N49°5E	88°	0·999	+0·070
27	Sept. 11, 1952	29°S	177°W	0·00R	N33°E	–	90°	1·000	0·000	N57°W	N33°E	84°	1·000	0·000
28	Mar. 23, 1951	31°S	180°	0·04R	N33°E	N57°W	86°	0·906	−0·423	N59°W	S31°W	66°	0·998	−0·070
	New Zealand													
29	Sept. 29, 1953	36½°S	177°E	0·04R	N54°E	S36°E	87°	1·000	+0·017	N36°W	S54°W	89°	0·999	+0·052
30	Jan. 13, 1954	49°S	165°E	0·00R	N43°5E	S46°5E	86°	0·988	+0·156	N45°5W	S44°5W	81°	0·998	+0·070

* After Webb, Reference 10. † After Hodgson and Storey, Reference 3.

Table XXVII is divided into three principal columns. The first column gives the time, location and depth of focus of the earthquakes and assigns numbers to them. These numbers will be used in subsequent tables and diagrams. In assigning numbers, the earthquakes have been grouped by geographical areas, and within each area the shocks have been arranged by latitude, from north to south. Within a particular area increasing number therefore indicates increasing southern latitude. Where two earthquakes have the same latitude they are listed in chronological order.

Since there is no way of recognizing which of the two planes obtained in any solution is the fault plane it is necessary to have two principal columns, corresponding to the possibilities *a* and *b* shown in the diagrams. In Table XXVII the plane which strikes into the northeast quadrant has been designated *a*, that which strikes into the northwest quadrant being called *b*. The diagrams of the present paper are consistent with this convention; it has been necessary however to change the published designation in the case of earthquakes 5 and 6.

For each of the possibilities *a* and *b* the strike and dip of the plane, and the direction of dip, have been listed. In each case too a unit vector, drawn in the direction of displacement has been resolved in the direction of strike and in the direction of dip. Where the dip component indicates that the hangingwall moved up the footwall, presumably indicative of a state of compression, a prefix + has been used. Conversely, where the dip component indicates that the hangingwall moved down the footwall, indicating a state of tension, a prefix − has been attached to the dip component.

Nature of the Faulting

By comparing the displacement in the strike direction with that in the dip direction, we find that in all but three cases the faulting is strike-slip, or transcurrent. The three possible exceptions are provided by the non-defined solution of earthquake 8, by the partially defined solution of earthquake 4, and by case *a* of earthquake 24. In the two former cases, which are not closely defined, transcurrent faulting is not ruled out. It must therefore be concluded that in the southwest Pacific the faulting is predominantly transcurrent.

Table XXVIII

Relation of Compressional (+) and Tensional (−) Dip Components To Focal Depth

Focal Depth	Area: Solomon Islands −	Solomon Islands +	New Hebrides Islands −	New Hebrides Islands +	Fiji −	Fiji +	Tonga Islands −	Tonga Islands +	Kermadec Islands −	Kermadec Islands +	New Zealand −	New Zealand +	Total −	Total +
·09R									1				1	
·07R								1						1
·05R				1										1
·04R									1			1	1	1
·03R			1	2				1					1	3
·02R			1										1	
·01R		1		1				2						4
·00R				9	1		1	1		1		1	2	12

Admitting that the strike component is the principal one, can we draw any inference from the sign of the dip component? In Table XXVIII the sign of this component, as defined in the paragraph above, has been summarized for each geographical area and for each focal depth. It is clear that there is no simple relationship between the sign of the dip component and the focal depth of the earthquakes, although it may well be that where the dip component is so small its sign is a matter of accident.

We conclude that faulting is transcurrent and that the direction of dip displacement is apparently random.

Direction of Faulting

Direction of Strike

Figures 24, 25 and 26 have been prepared to investigate whether there is any systematic direction of faulting in the various geographic areas. In Figure 24 the strike directions of each of the planes *a* and *b* for the New Hebrides earthquakes have been plotted, the direction of the line indicating the direction of the strike and the length of line indicating the focal depth of the earthquake according to the indicated scale. Recalling that plane *a* is constrained by definition to lie in the northeast quadrant and plane *b* in the northwest one, it is quite clear that there is no systematic arrangement of strike direction. This is true whether we consider the data as a whole or consider specific ranges of focal depth. It will be recalled that numbers were assigned to the earthquakes in the order of their distribution from north to south; the erratic distribution of the numbers in the figure shows that there is no systematic variation of strike direction with epicentre location.

Figures 25 and 26 present similar data for the Tonga and Kermadec earthquakes. While the data in these cases are too few to allow a final conclusion to be drawn, certainly there is no clear indication of any relation between strike direction and either focal depth or geographical location.

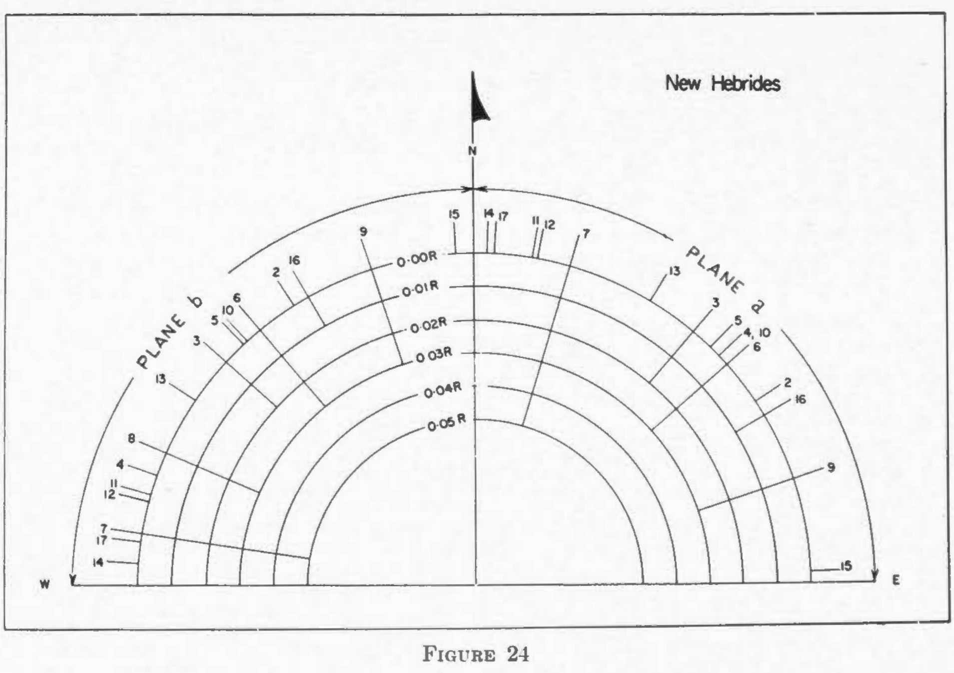


FIGURE 24

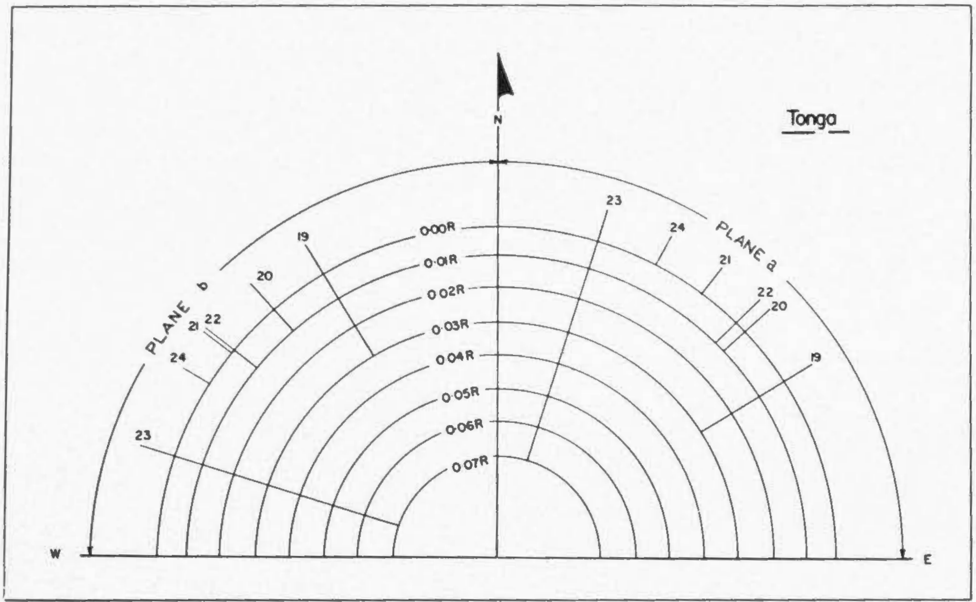


FIGURE 25

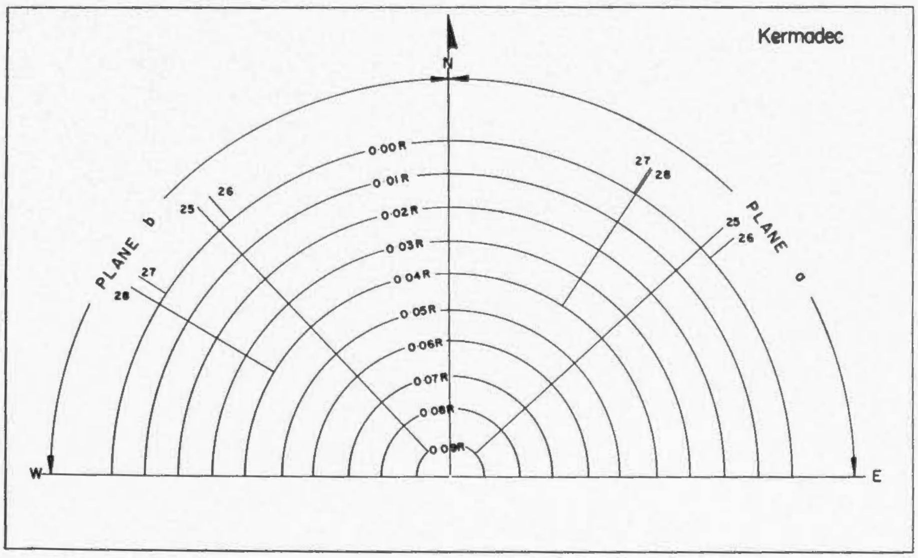


FIGURE 26

Direction of Dip

The dip of a plane is more significant than its strike, for it is a true vector quantity giving both the direction and amount of dip. In order to indicate both these quantities we shall make use of a stereographic projection of the type shown in Figure 27. The upper section of the figure represents the sphere of the earth with an epicentre at E and a line EP, striking the earth at P, representing the dip direction of a plane. Whereas normally in the fault-plane work we have used the anticentre of the earthquake as the pole of projection, we shall here use the epicentre itself as the pole, and project on the equatorial plane. This has the advantage that points near the anticentre of the earthquake, such as P, will plot into a finite region.

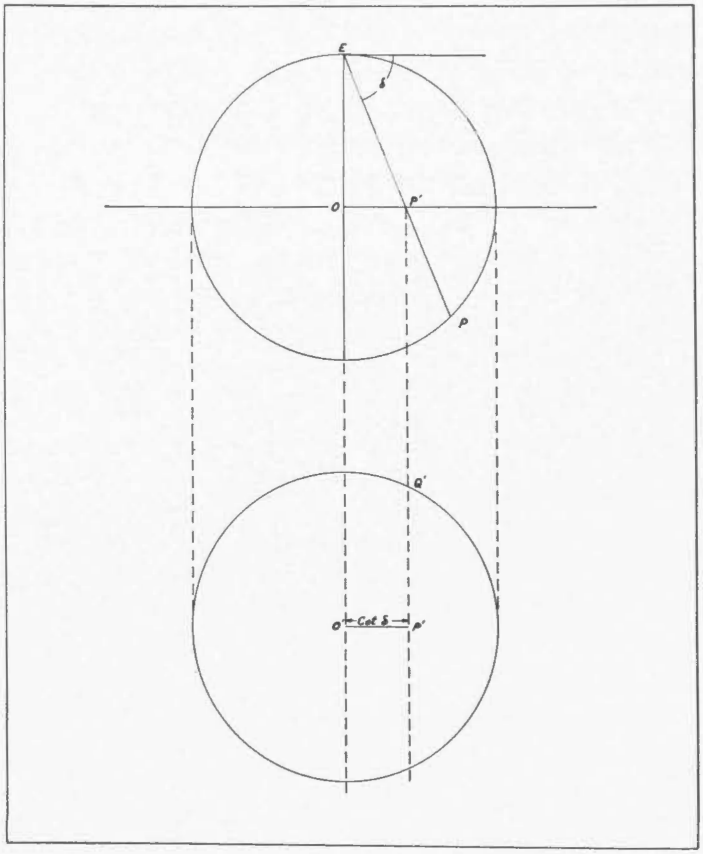


FIGURE 27

The lower section of the diagram indicates the map produced by the projection. The point P projects into a point P′ at the same azimuth as P, and at a distance $=\cot\,\delta$ from the centre. It will be helpful to make one further observation about the projection. Suppose that, in the upper section of the diagram, a plane be drawn through EP perpendicular to the paper. EP would represent the dip direction of this plane. In the projection the plane would become the straight line P′Q′, at right angles to the line joining P′ to the centre of the map.

Turning now to the data on dip given in Table XXVII, we plot the dip vectors of planes *a* and *b* in the projection just described. The results for the New Hebrides are shown in Figure 28. In plotting all the data on a single figure we are essentially regarding the dip vectors as free vectors, and moving them to a single origin. Dip vectors associated with planes *a* have been indicated by open symbols, those associated with planes *b* by closed ones. It is worth stressing once again that the designation of plane *a* as that one striking into the northeast quadrant was arbitrary, and there is no assurance that the open symbols, for example, do designate a connected system. Nevertheless it is remarkable that except for earthquake 15 the open symbols lie between parallel lines striking N 58° W and representing planes, one dipping SW at an angle of 83° and the other dipping NE at an angle of 84°. Similarly, with the exception again of epicentre 15, the closed symbols are confined between lines striking N 13° E and dipping NW at an angle of 86° and SE at an angle of 83°. If we

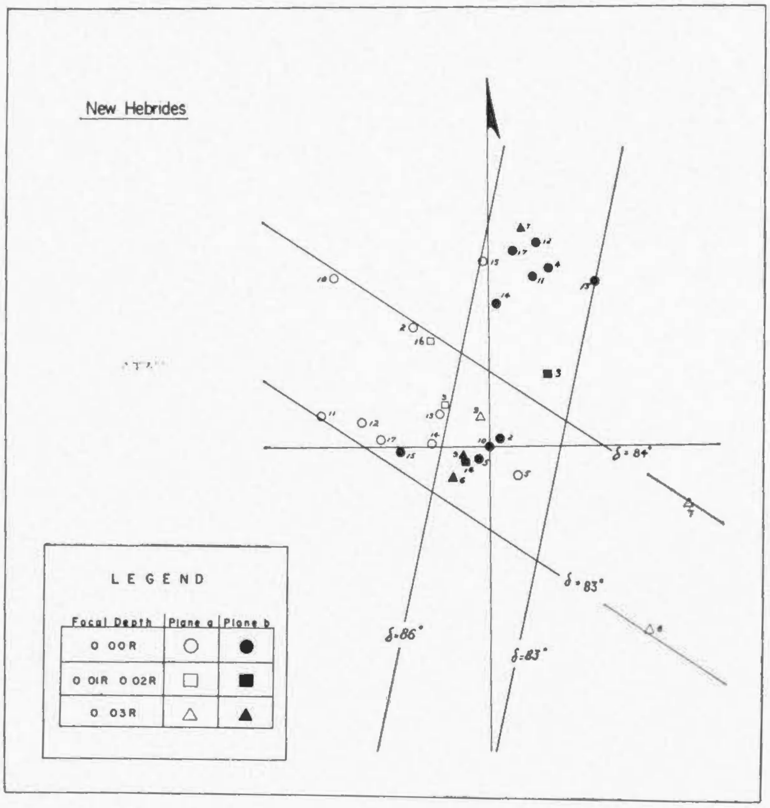


FIGURE 28

were to interchange the designations a and b for earthquake 15 there would be no inconsistencies in the pattern. This interchange is quite justified since the original designation was arbitrary.

We have then the surprising conclusion that the dip vectors of the New Hebrides earthquakes lie nearly parallel to a pair of vertical planes, one striking N 13° E, the other N 58° W. Is it significant that the mean of these two directions is N 22°.5 E, almost exactly the direction of the geographical feature?

The plot of equivalent data for the Tonga-Kermadec-New Zealand earthquakes is given in Figure 29. In this case the closed symbols lie parallel to a plane striking N 33° E and dipping to the NW at an angle of 87° ±5°. The open symbols lie so closely grouped around the origin that it is not possible to define a plane. In this case in fact the dip vectors might be said to define a single direction.

With only one set of planes defined it is not possible to investigate whether the mean direction of the planes is the same as the direction of the feature, but in this case it seems improbable. The mean direction of the Tonga-Kermadec-New Zealand feature is about N 24° E. The solid symbols in Figure 29 define an angle N 33° E; to give the proper mean the open symbols would have to define a plane striking N 15° E. There is no evidence in support of this direction. However, even without this, the alignments shown in Figures 28 and 29 must be regarded as remarkable.

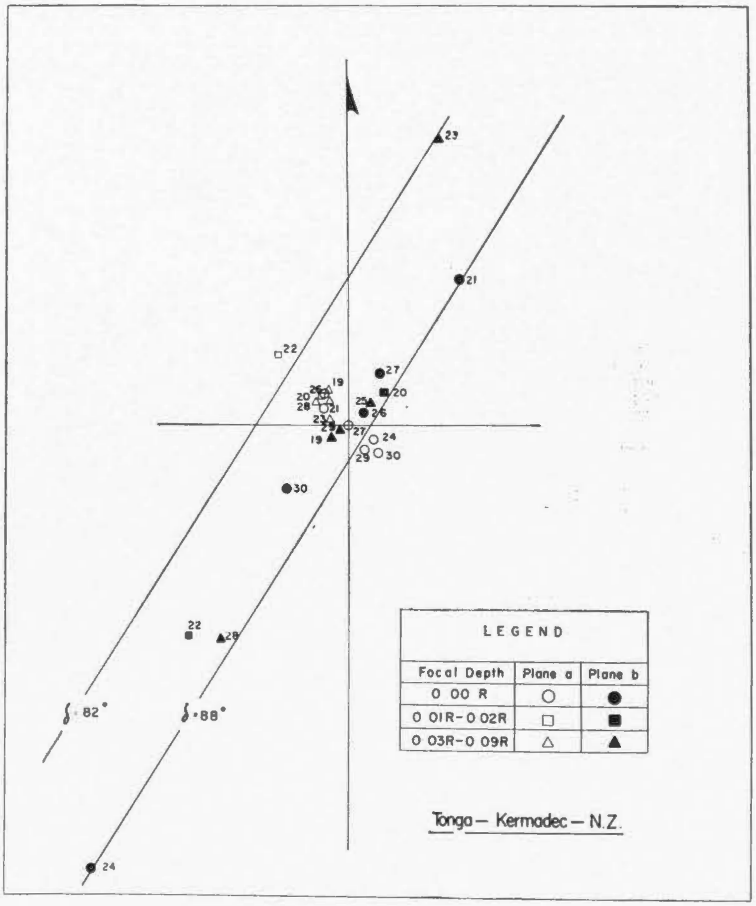


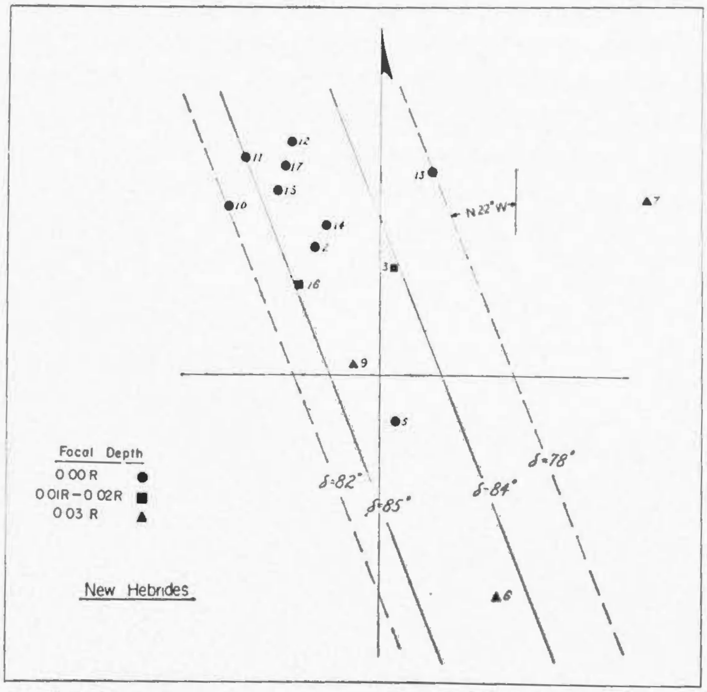
FIGURE 29

Direction of the Null Vector

It may be objected that the patterns shown in Figures 28 and 29 depend on an arbitrary designation of planes *a* and *b* and that this renders the conclusions of no significance. There is one line in each fault-plane solution which avoids this criticism. This is the line joining the two points of intersection of circles *a* and *b*. Provided the solution is closely defined, we can determine in each case the direction and dip of this line. These have been summarized in Table IXXX.

What is the significance of this line? It is a line common to both planes *a* and *b*, and therefore perpendicular to the motion vector, whichever plane represents the fault. It is in fact the axis of the displacement couple, and as such it is the one line in space which certainly undergoes no motion. For that reason we may call it the *null vector.*

In Figure 30 we have plotted on the special projection already described the points of emergence of the null vectors for the New Hebrides earthquakes. Because solutions 4 and 8 were not well defined it has not been possible to define the null vectors in those cases. With the exception of earthquake 7, all the null vectors lie between planes striking N 22° W and dipping respectively 82° to the SW and 78° to the NE. If we were to except



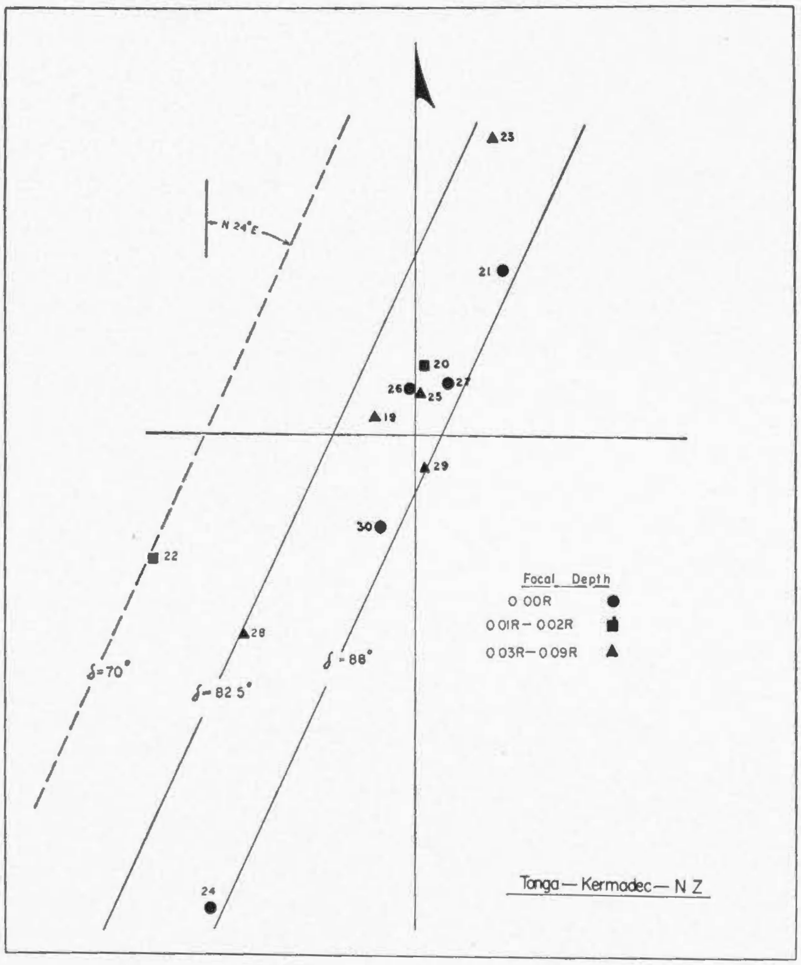


FIGURE 30 and 31.

earthquakes 10 and 13, the dips of these planes could be reduced to 85° and 84° respectively. As already stated the direction N 22° E is a very good value for the strike of the geographical feature.

Figure 31 presents the equivalent diagram for the null vectors of earthquakes of the Tonga-Kermadec-New Zealand area. The vectors clearly define a plane striking N 24° E and dipping to the NW at an angle of 79° ±9°. If earthquake 22 is ignored, this dip is 87° ±5°. As stated earlier, the best average direction for the geographic feature is N 24° E.

We have then the conclusion that the null vectors in southwestern Pacific earthquakes lie parallel, within narrow limits, to planes having the strike of the geographic feature.

It is generally agreed, on the basis of the epicentres and focal depths of earthquakes, (see for example, Gutenberg and Richter[9]), that the foci of New Hebrides earthquakes define a plane having the strike of the feature and dipping to the NE at an angle of some

TABLE XXIX

STRIKE AND DIP OF THE NULL VECTORS

Earthquake Number	Strike	Dip
Solomon Islands		
1	S87°E	50°
New Hebrides Islands		
2	N27°5W	75°8
3	N8°E	79°3
5	S20°E	85°2
6	S28°5E	66°4
7	N56·5E	60°6
9	N65°W	87°
10	N43°W	68°
11	N32°W	65°5
12	N21°W	66°2
13	N14°5E	69°7
14	N20°W	74°3
15	N29°W	69°5
16	N44°W	77°8
17	N25°W	67°9
Fiji Islands		
18	N9°W	82°9
Tonga Islands		
19	N66°W	85°5
20	N7°E	82°9
21	N28°E	71°8
22	S65°W	62°8
23	N14°E	61°5
24	S23°5W	47°8
Kermadec Islands		
25	N6°E	86°
26	N6°W	85°2
27	N33°E	84°
28	S41°W	65°
New Zealand		
29	S19°E	86°5
30	S21°W	80°3

70°. Similarly the foci of the Tonga-Kermadec earthquakes appear to define a plane having the strike of the feature and dipping to the NW at an angle of about 45°. It should be remarked that, while the planes defined by the null vectors are approximately vertical they both have a slight preference for the direction of dip defined by the earthquake foci.

One other point is worth making. It will be recalled that increasing number indicates increasing southern latitude within any feature. Examining Figure 30, we find a systematic progression through points 3, 5 and 6, and a close grouping of numbers 10 to 17. This latter group of points derive from earthquakes lying between 20° S and 21° S. The range of latitude involved in Figure 31 is much greater than that for Figure 30, but the steady progression of points 19, 20, and 21 and the close grouping of points 25, 26 and 27 probably has significance. It seems possible that not only do the vectors for an entire feature define a plane, but also that the vectors for a particular part of the feature define a unique direction. Substantiation of this point will have to await the accumulation of much more data.

Is there any relationship between point of emergence of the null vector and focal depth? The focal depths of the earthquakes have been indicated in Figures 30 and 31 by symbols. There does not seem to be any systematic distribution of the deep or intermediate focus symbols.

Two earthquakes, number 1 in the Solomon Islands and number 18 in the Fiji Islands, have been omitted from this discussion. At the point of epicentre 1 the Solomon Islands have a strike of about S 60° E, so that null vector strike of S 87° E does not differ too much from the direction of the feature. It is almost impossible to assign a direction to the Fiji group of islands, against which to check the direction of the null vector. A line connecting the islands would strike slightly west of north, which would be consistent with the null vector direction of N 9° W. At least it may be concluded that there is no obvious inconsistency shown by these two earthquakes to the conclusion that the plane of the null vectors is approximately parallel to the strike.

Discussion

Until analysis similar to that of this section has been applied to earthquakes of other areas the patterns found in the southwest Pacific must be regarded as local ones. So far their physical significance is uncertain, but one conclusion may safely be drawn. The correlation between the strike of the geographical feature and the plane defined by the null vector can scarcely be accidental. Under the circumstances, the techniques of the fault-plane project receive a considerable degree of confirmation, for in the hands of two different operators, and over a period of five years, it has produced results which are not only consistent with themselves but which also indicate relationships with the geographical features of the area.

CONCLUSIONS

Thirty earthquakes, 16 of them associated with the New Hebrides feature and 12 of them with the Tonga-Kermadec-New Zealand feature, and occurring over a period of more than five years have been analysed by the fault-plane techniques by two different investigators. These fault-plane solutions would support the following conclusions:

1. Faulting in the southwest Pacific is predominately transcurrent along steeply dipping planes.

2. There is no consistency in the strike direction of the faults, nor any systematic variation either with latitude, depth of focus or position on the associated arcuate feature.

3. Vectors drawn in the direction of maximum dip of the two planes obtained in any solution tend to lie parallel to two nearly vertical planes; the relationship between the strike of these planes and the strike of the associated feature is not clear.

4. Defining the null vector as that vector common to the two planes, and therefore perpendicular to the displacement couple whichever plane represents the fault, it is found that the null vector has a strong tendency to lie parallel to an almost vertical plane having the strike direction of the associated geographic feature. There is also the suggestion, which the data are too few to establish for certain, that for any closely associated group of epicentres there tends to be a unique direction for the null vector.

5. These relationships, although their physical significance is still obscure, tend to confirm the validity of the techniques of analysis used in these studies of earthquake fault-planes.

ACKNOWLEDGEMENTS

The compilation of data and the original plotting of the 1951 earthquakes was carried out by J. F. J. Allen. Similar work for the more recent earthquakes was done by R. R. Clark. The figures have been drawn by Mrs. I. H. Blüme and P. J. Winter. I am very grateful for all this help. I am also much indebted to my colleague Dr. P. L. Willmore for helpful discussion on the fault-plane results; in particular, it was a suggestion of Dr. Willmore's that led to the plotting of the null vectors.