CANADA

DEPARTMENT OF MINES AND TECHNICAL SURVEYS

DOMINION OBSERVATORIES

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

Volume VII

OTTAWA
EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
KING'S PRINTER AND CONTROLLER OF STATIONERY
1951

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DEPARTMENT OF THE INTERIOR
CANADA

HON. CHARLES STEWART, *Minister* W. W. CORY, C.M.G., *Deputy Minister*

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

R. MELDRUM STEWART, M.A., *Director*

Vol. VII

SEISMOLOGY

No. 1

REPORT OF THE SEISMOLOGIC DIVISION FOR 1923

BY

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OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1925

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REPORT OF THE SEISMOLOGIC DIVISION FOR 1923

GENERAL INTRODUCTION TO VOLUME VII

The seismologic publications resulting from the work done at the Dominion Observatory, Ottawa, have been printed in various journals, in reports other than the *Publications of the Dominion Observatory* (hereafter referred to briefly as the *Publications*), and in scattered numbers of these *Publications*. They were written by Dr. Otto Klotz, Ernest A. Hodgson, or W. W. Doxsee. All of those by Mr. Doxsee have appeared in the series but those by Dr. Klotz and by Mr. Hodgson have not. As no complete list of these papers has been previously compiled, it seems worth while to make one now. The list has been divided into three parts—The Seismologic Papers of Dr. Otto Klotz, not appearing in the *Publications;* The Seismologic Papers of Ernest A. Hodgson, not appearing in the *Publications;* and the Seismologic Numbers, appearing previous to 1924, in the *Publications.* They are printed as an appendix to this number.

It is planned that the seismologic papers which appear hereafter as part of the series of *Publications* are to be confined to a single volume until that is filled. Then the next unopened volume will be reserved for seismology, till filled—and so on.

It may be pointed out here that *The Location of Epicentres, 1920,* by W. W. Doxsee' M.A., Vol. VIII, No. 2, 1922, was published at the time this scheme was being planned but too soon to be held for Vol. VII, which, it had been decided, was to be reserved for seismology. Thus the locations for 1920 appear in Vol. VIII, while the locations for 1921, next to be issued, will be published as a part of Vol. VII. However, a start had to be made and it was felt that all the papers in seismology should be put into the same volume after 1924, regardless of this single, apparently anomalous, instance of numbering.

A publication is now being prepared giving general details of the work done in seismology, at the Dominion Observatory, from the time the first seismograph was installed until 1924, and giving full details of the system of recording and office management now in use. An outline will be given of the records now on hand, their nature and quality, and a report on the series of records at present being compiled will be included. It is planned to make the article very detailed, in order that the material now available may be made known to any whose researches may require it and to act as a suggestion to others, as well as to prompt suggestions from others as to changes or improvements likely to add to the value of the co-operative work now being carried on by so many seismologic stations.

The report which follows for 1923 is the first of a series of annual reports to appear along with other papers in the seismologic volumes of the *Publications.* Each will outline the work done in seismology during the year. Changes deemed advisable in the system of office management and in the programme of recording will be made, where necessary, only at the end of each year. These changes will be outlined in the next succeeding report, to supplement the information to be given in the article outlined in the previous paragraph. Any seismologic papers published elsewhere than in the regular series, *Publications of the Dominion Observatory*, which appear during the year under report, will be listed each year to supplement the list appearing in the appendix to this number.

The work being done will thus be readily followed by anyone interested in making use of the records, and everything in that line done by this division of the Dominion Observatory will be found, in detail or as a reference, within the seismologic volumes of the *Publications*, the first of which is the present volume.

INTRODUCTION TO THE REPORT FOR 1923

The work in seismology at the Dominion Observatory was begun in 1905 by Dr. Otto Klotz. Since that time he was constantly in touch with it. After becoming Director, in 1917, he still maintained an active interest. His death on December 28, 1923, is a loss which will be felt by this division for many years. His contributions to the science and the memory of his efforts to make Canada's part in it of value to the world will, however, continue to live, long after the feeling of loss at his death has begun to be softened by time. This is as he would have wanted it to be and as any man, working as he did for the love of a science, must wish.

This report is the first complete outline of the seismologic activities of this observatory issued since 1912, when Dr. Klotz, in Appendix I to the Report of the Chief Astronomer for 1911, gave a description of the work for the year covered by the report. Since then papers covering parts of the investigations have been printed from time to time but no reports on the work as a whole have been published.

For the purpose of ready reference, the report is divided into sections.

EARTHQUAKES RECORDED

During the year 308 earthquakes were registered, of which a large percentage were visible only on the Milne-Shaw sheets. These are reported in tabular form.

The Milne-Shaw seismographs are mounted on a pier 8 feet square, in a vault 20 feet below the surface of the ground. No building is above this vault. The temperature is constant within a few degrees throughout the year and there is practically no daily variation. The constant temperature and the freedom from local disturbances enable the magnification to be set at 250 fold, resulting in greater sensitivity for these intruments than for the Bosch, which are mounted in the basement of the observatory.

Reports on the records have been published monthly as bulletins. The mailing list in 1922 contained 120 addresses; this number was increased in 1923 to 230. All well-marked earthquakes were reported to the press.

A request was made with the January issue that the stations receiving that bulletin would fill out and return a receipt form, as it was felt that the mailing list should be kept free of stations no longer in operation. As soon as a single receipt was received here, the station reporting was put in a special list and receipt forms were no longer sent out to it in succeeding bulletins. At the end of the year over thirty stations had not yet returned any receipt. The practice will be continued of requesting the return of one, and only one, receipt per year from stations receiving our bulletins.

Beginning with January, 1924, a list has been sent out with each bulletin from this station acknowledging the receipt of reports from other observatories. The bulletins received during December, 1923, were so acknowledged. This method will be continued in the future.

The constants of the seismographs were given each month on the first page of the bulletin. The outline of these for the year, in tabular form, follows the list of earthquakes.

TABULAR LIST OF EARTHQUAKES

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1371								
Jan. 2	e_E	22–58–42						N-S lost in heavy micros.
	eL	23–09·5	22					
	L	23–17						
Jan. 3	F	0–05 ca						
1372								
Jan. 8	i_E	22–12–08						
	eL	22–24·5						
	F	22–50						
1373								
Jan. 11	e_E	4–46						
	eL_E	4–47·5						
	M_E	4–48·8						
	F	4–57						
1374								
Jan. 12	eL_E	19–50						Barely discernible on No. 17.
	L_E	19–55						
	F	20–05						
1375								
Jan. 12	e_E	21–31						Very faintly recorded on No. 17 only.
	eL_E	21–33						
	F							Lost in micros.
1376								
Jan. 14	eL_E	13–35 to 13–50						Can just be detected.
	F							Lost in micros.

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude			Distance	Remarks
				A_E	A_N	A_Z		
		h m s	s	μ	μ	μ	km.	
1377								
Jan. 20	i_E	21-57-41						
	eL_E	22-08						
	L_E	22-16	21					
	F	22-35						
1378								
Jan. 21	i_E	4-33-37						On No. 17 only.
	eL_E	4-55	12					
	L_E	4-59 to 5-06						
	F	5-26						
1379								
Jan. 21	e	14-07·5						Sinusoidal L waves of small amplitude and with a beautiful gradation in period from 28s to 15s.
	eS?	14-09·7						
	eL	14-32						
	L	14-34	28					
	L	14-57	15					
	F	15-00 ca						
1380								
Jan. 22	$e?_{17}$	1-18						Micros obscure N-S.
	e	1-20·3						
	e	1-22						
	$eS?_E$	1-23-48						
	eL_E	1-39						Sinusoidal L waves of small amplitude predominate.
	L_E	1-54						
	L_E	2-10	19					
	F	3-25						
1381								
Jan. 22	O	9-04-10					3880	Press reports tremor felt at Sacramento, Cal., and Reno, Nev.
	P	9-11-19						
	PR_2	9-12-30						
	S	9-16-59						
	SR_2	9-19-17						
	eL	9-20-44						
	M_{17}	9-26-45	19	500				
	F	12-00 ca						
1382								
Jan. 26	e	21-50-28						Faint traces only.
	i	21-52						
	eL	22-00						
	F	22-30						
1383								
Jan. 27	e	8-09-41						
	eL	8-14						
	M_1	8-16-08						
	M_2	8-17-23						
	F	9-09						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1384								
Feb. 1	e_E	19-45-38						
	e_E	19-55-38						
	eL_E	20-02-39						Sinusoidal L waves.
	L	20-21	34	63				
	L	20-36	18					
	F	21-50						
1385								
Feb. 2	O	1-16-53					6500	
	P	1-26-53						
	S	1-34-56						
	L	1-41-46						
	M	1-49	20	38				
	L	1-56						
	F							Lost in micros at 3-25 ca.
1386								
Feb. 2	O	5-08-21					7260	
	P	5-19-03						
	S	5-27-45						
	SR_1	5-32-41						
	eL	5-36-00						
	L	5-40	43					
	M_{1E}	5-48	17	140				
	M_{2E}	5-54	17	140				
	L	6-05	15					
	L	6-20	16					
	L	6-40	15					
	L	6-55	15					
	L	7-25	15					
	L	7-51	15					
	L	8-00	15					
	L	8-20	15					
	F	9-10 ca						
1387								
Feb. 3	O	16-01-56					7620	The Saskatoon and Halifax records indicate, respectively, distances of 5750 km. and 8440 (?) km.
	P	16-12-57						
	S	16-21-58						
	SR_2	16-29-50						
	eL	16-34-00						
	M_1	16-42						
	M_2	16-45-40	16	4400				
	L	17-00	16					
	L	18-00	16					
	L	19-00	16					
	L	20-00	16					
	L	21-00	14					
	L	23-04						
Feb. 4	L	1-49						
	L	6-42						
	F	7-00						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1388								
Feb. 4	eL	11-47						Small amplitude L waves—an "after quake" to No. 1387.
	eL	12-55						
	eL	13-08						
	F	14-10						
1389								
Feb. 4	eL	16-20						Very faint traces only. Recorded only on M-S.
	F	17-00						
1390								
Feb. 4	eL	17-55						Very faint traces only. Recorded only on M-S.
	F	18-07						
1391								
Feb. 4	eL	18-51						
	L	19-10						
	L	19-15	16					
	F	19-25						
1392								
Feb. 5	e	3-30						
	eL	4-00						
	L	4-04	13					
	F	4-40						
1393								
Feb. 5	eL_E	8-37						
	F	8-55 ca						
1394								
Feb. 5	L_E	12-21						
	F	12-50 ca						
1395								
Feb. 5	eL_E	23-01·5						
	L_E	23-03	15					
	L_E	23-26						
	L_E	23-35	15					
	L_E	23-40						
Feb. 6	F	0-05 ca						
1396								
Feb. 6	eL	13-06						Faint traces only.
	F	13-25 ca						
1397								
Feb. 6	eL	22-28						Faint traces only.
	F	22-45 ca						
1398								
Feb. 8	O	0-33-23					3660	
	P	0-40-15						
	S	0-45-42						
	eL	0-50						
	L	0-52						
	L	1-04						
	F	1-30 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1399								
Feb. 8	eL	3-56	36					
	L	4-00	22					
	L	4-10	15					
	F	4-20						
1400								
Feb. 8	e?	7-53·3						
	e?	8-02						
	eL	8-26	22					
	L	8-29						
	L	8-38	15					
	F	9-10						
1401								
Feb. 8	e	14-24·2						
	eL	14-32						
	F							Lost in changing the records.
1402								
Feb. 9	eL_E	11-33						Traces very small.
	eL_E	12-05						
	F	12-28						
1403								
Feb. 11	eL_E	1-50						
	L_E	1-53						
	L_E	2-00						
	F	2-10						
1404								
Feb. 11	e	17-43						Small amplitudes only.
	eL	17-49	18					
	L	17-50	15					
	F	18-27						
1405								
Feb. 11	O?	22-59-47					(2930)	A curious phenomenon is the appearance at 0-35·5 of what was at first believed to be LR_1. It appeared at the minute expected but one hour too early. The true interpretation of this increase in period of the L waves is not known. It would be interesting to know whether other stations found the same period increase on their records.
	P?	23-05-37						
	S?	23-10-15						
	eL	23-13·0						
	L	23-25	16					
	L	23-32	16					
	L	23-43	15					
Feb. 12	L	0-05	15					
	L	0-35·5	30					
	F	0-55						Δ may be much greater—of the order of 10000 km. with the P wave missing. Not much success has resulted from our attempts to so read it.

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1406								
Feb. 12	O	2-09-01					6160	
	P	2-18-41						
	S	2-26-26						
	eL	2-31						
	L	2-35·5						
	M_E	2-43	22	58				
	L	3-00 to						
		3-45						
	F	4-10 ca						
1407								
Feb. 12	eL_E	13-18						
	L_E	13-22						
	F	13-38						
1408								
Feb. 14	eL_E	17-59						Faint traces only.
	L_E	18-08						
	F	18-22 ca						
1409								
Feb. 15	eL	23-14 to						Heavy micros mask much.
		23-31						
1410								
Feb. 16	L	7-15·7						Heavy micros mask much.
	F	7-35						
1411								
Feb. 16	e	9-37·6						Heavy micros mask much.
	eL	9-50·5						
	F	10-12 ca						
1412								
Feb. 18	O	23-50-25					5880	
	P	23-59-49						
Feb. 19	S	0-07-19						
	eL	0-12·5						L waves taper off to very small amplitudes after M has passed.
	L	0-17						
	M_E	0-23-24	19	26				
	F	2-00						
1413								
Feb. 19	e_E	6-39-26						
	e_E	6-51·4						
	e_E	6-56·2						
	eL_E	7-10						
	L_E	7-17						
	L_E	7-36·5						
	F	8-25 ca						
1414								
Feb. 21	eL	1-01						Small amplitudes.
	L	1-09						
	L	1-20						
	L	1-32						
	F	1-50 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1415 Feb. 21	e	3-40						Small amplitudes.
	eL	3-46						
	L	4-00						
	L	4-15						
	L	4-25						
	F	4-45 ca						
1416 Feb. 23	O	6-05-28					4750	
	P	6-13-39						
	i	6-14-23						
	S	6-20-08						
	eL	6-25·5						Periods of L waves very irregular, amplitudes small.
	L	6-31						
	L	6-43						
	L	6-53						
	L	7-04						
	F	8-17						
1417 Feb. 24	O	7-34-48					7390	
	P	7-45-37						
	S	7-54-26						
	SR_1	7-59-32						
	SR_2	8-02-08						
	eL	8-05	45					
	L	8-10						
	M_E	8-14·5	16	410				
	L	8-20 to						
		11-00	8					
	F	11-40						
	HALIFAX RECORD							
	O	7-36-40					7620	
	P	7-47-41						
	S	7-56-42						
	eL	8-04						
	M_1	8-15						
	M_2	8-21						
	F	9-20 ca						
	SASKATOON RECORD							
	O	7-36-34					5400	The difference in time for O is probably due to clock errors in Saskatoon and Halifax. The values of Δ for Ottawa and Saskatoon give an intersection at Kamchatka. Strasbourg wireless gives the epicentre as Kamchatka.
	P	7-45-28						
	S	7-52-32						
	eL	8-00						
	L	8-02						
	M_1	8-05·5						
	M_2	8-11·5						
	F	9-00 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1418								
Feb. 24	eL	18-58						
	F	19-05						
1419								
Feb. 25	eL	4-37						Very small amplitudes only.
	L	4-39						
	F	5-00						
1420								
Feb. 27	O	20-39-12					2850	
	P	20-44-54						
	S	20-49-26						
	eL	20-51-38						
	L	20-53-45						
	F	21-30 ca						
1421								
Feb. 28	O	(22-20-33)					(2640)	Small amplitudes only.
	P?	22-25-55						
	S	22-30-11						
	eL	22-34						
	M	22-38						
	F	23-18						
1422								
Mar. 1	O	(8-26-15)					(6240)	Small amplitudes only.
	P	(8-36-00)						
	S	8-43-49						
	i	8-45-47						
	i	8-47-38						
	eL	8-53						
	L	8-56						
	L	9-00 to						
		10-00						
	F	11-00 ca						
1423								
Mar. 2	e?	17-01-44						Halifax record contains traces of L waves but no P or S.
	eS?	17-09-32						
	i	17-19-49						
	i	17-26-45						
	L	17-43						
	M	17-57	23					
	L	18-09	21					
	L	18-36	19					
	F	20-05						
1424								
Mar. 3	i	22-33-18						Very small amplitudes.
	e	22-42-00						
	eL	22-57						
	L	23-05 to						
		23-25						
	F	23-53						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1425 Mar. 4	eL	0-29						Traces only.
	L	0-36						
	F	1-15 ca						
1426 Mar. 4	eL	7-44						Very small amplitudes.
	L	7-47 to 8-26						
	F	9-30						
1427 Mar. 10	eL	0-02						
	L	0-08						
	F	0-38						
1428 Mar. 10	e	8-33						
	e(L or S)	8-38						
	L	8-55						
	L	9-00·5						
	F	9-40 ca						
1429 Mar. 11	O	23-06-45					3960	Small amplitudes only.
	P	23-14-00						
	S	23-19-45						
	eL	23-25						
	M	23-29						
	F	0-15 ca						
1430 Mar. 12	eL	10-25						
	L	10-34						
	F	10-50						
1431 Mar. 13	i	20-08-38						
	eL	20-19·5						
	L	20-24·5 to 20-45						
	F	21-15 ca						
1432 Mar. 14	O	(20-54-49)					(6580)	Very small amplitudes throughout.
	P	(21-04-53)						
	S	(21-13-00)						
	eL	21-21·5						
	L	21-43						
	M_1	21-49	22					
	M_2	21-54·5	21					
	L	22-02	19					
	L	22-08	18					
	L	22-12·5	16					
	F	23-15 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
1433		h m s	s	μ	μ	μ	km.	
Mar. 15	O	5-40-16					7020	
	P	5-50-45						
	S	5-59-15						
	eL	6-05·5						
	M	6-18						
	F	7-35 ca						
1434								
Mar. 16	O	22-12-33					6320	Strasbourg wireless gives
	P	22-22-22						O=22-15-45
	S	22-30-15						Δ=12500 km.
	eL	22-39-15						
	L	22-58	32					
	M	23-12	22					
	L	23-16	19					
	L	23-23	17					
	L	23-30 to						
Mar. 17		0-00	15					
	L	0-05	14					
	F	1-05 ca						
1435								
Mar. 18	eL	20-45-15						
	L	20-45·8						
	M	20-48						
	F							Micros interfere.
1436								
Mar. 19	e	11-23						
	S?	11-26-32						
	L	11-29						
	M	11-35						
	F	12-27 ca						
1437								
Mar. 19	eL	16-57						
	L	17-15						
	L	17-20						
	L	17-28						
	F	17-45 ca						
1438								
Mar. 19	eL	21-56						Small amplitudes.
	L	22-03·5						
	L	22-05						
	F	22-30 ca						
1439								
Mar. 24	e	2-37						Small amplitudes.
	L	2-41						
	F	3-00 ca						
1440								
Mar. 24	e	8-51·4						
	L	8-55·4						
	L	8-57						
	F	9-10 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1441 Mar. 24	e_E	13-00·6						Earthquake does not appear to have been a single abrupt shock. The phases seem to result from several shocks and do not admit of resolution.
	e	13-04-53						
	S	13-06						
	eL	13-18						
	L	13-25						
	M_1	13-38·5	30					
	M_2	13-42·5	26					
	L	13-43 to						
		14-00	18					
	L	14-10 to						
		15-45	13					
	F	15-30 ca						
1442 Mar. 26	eL_E	14-57						Small sinusoidal L waves
	L_E	15-00	40					
	L_E	15-02·5	24					
	L_E	15-10·5	21					
	L_E	15-14	18					
	L_E	15-24·5	22					
	L_E	15-32	20					
	F	15-49 ca						
1443 Mar. 28	e	(5-10)						Times uncertain. Time signals faint owing to the intensity of the light spot.
	e	(5-15)						
	eL?	(5-21)						
	L	(5-26 to						
		6-20)						
	F	(6-30)						
1444 April 5	eL	(23-00)						Times uncertain owing to halation trouble on record.
	L	(23-06)						
	F	(23-20) ca						
1445 April 13	e	10-26-26						Small amplitudes and irregular periods.
	e	10-27-58						
	e	10-33-16						
	i or eL	10-36-08						
	L	11-20						
	eL	12-00						
	F	12-25						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1446 April 13	O	15-31-12					7380	
	P_M	15-42-00						On M-S only.
	S	15-50-48						
	SR_2	15-58-20						
	eL?	16-02						
	M_{1-17}	16-09	17	110				
	M_{2-17}	16-13	22	275				
	M_{3-17}	16-15	19	195				
	M_{4-17}	16-17	17	140				
	L	16-20 to	17					
		18-00	10					
	F	18-40						
1447 April 13	eL	21-16·5 to						
		21-26						
	F	21-37						
1448 April 14	eL_{17}	9-31·5 to						
		9-44						
	F	9-50 ca						
1449 April 14	eL	15-57						
	L	16-00 to						
		16-08						
	F							Lost in micros.
1450 April 19	e	3-31-41						
	eL?	3-51						
	L	4-05	45					
	L	4-12	32					
	L	4-25	22					
	L	4-39·5						
	L	4-50						
	L	5-03						
	F	5-45						
1451 April 23	O	3-33-48					5580	Very faintly recorded as to P and S.
	P	3-42-53						
	S	3-50-07						
	eL	3-58·5						
	L	4-04	45					
	L	4-10	30					
	M	4-16	17	26				
	L	4-24	14					
	L	4-31	11					
	F	5-25						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1452 April 24	eS?	22-58-15						Δ probably the same as for No. 1453. Very irregular periods.
	eL	23-04						
	M	23-05·5						
	F	23-37						
1453 April 25	O	19-31-46					4300	Irregular periods. Bears a striking resemblance to No. 1452.
	P	19-39-26						
	S	19-45-30						
	eL	19-50·5						
	M	19-52·5						
	L	19-55						
	L	20-07·5						
	F	20-50						
1454 April 27	e	10-49						
	eL	11-05·5						
	L	11-33	25					
	F	12-06						
1455 April 29	O	2-31-08					3900	Small amplitudes.
	P	2-38-19						
	S	2-44-00						
	eL?	2-49·5						
	L	2-51·7						
	M	2-54·4	12	12				
	F	3-35 ca						
1456 April 29	e?	9-46·4						Sinusoidal L waves of small amplitude.
	eL	9-56·5						
	L	10-10	30					
	L	10-19	21					
	L	10-24	18					
	L	10-27	16					
	F	10-44 ca						
1457 April 29	eL	19-33						Traces on M-S only.
	L	19-35	23					
	F	19-43						
1458 April 30	e?	16-37·5						
	eL	16-43						
	F	17-05						
1459 April 30	eL	20-55						
	L	20-58	23					
	L	21-11·5						
	F	21-20						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1460								
May 1	e	10–55						
	e	11–01						
	eS?	11–10–38						
	eL	11–17·5						
	L	11–34–44						
	F	12–05						
1461								
May 2	e	16–34–52						Irregular small periods.
	e	16–36–15						
	eL	16–41·5						
	L	16–42 to 17–05						
	F	17–30 ca						
1462								
May 4	O	16–26–34					5520	Harvard gives O=16–26–31 Δ=6040 km. Strasbourg gives O=16–26–35 Δ=8500 km. These values for Δ give circles which intersect at φ=54° N. λ=155° W., near Kodiak, Alaska.
	P	16–35–35						
	†PR_{1M}	16–37–34						
	PR_{2M}	(16–38–07)						
	S	16–42–45						
	i	16–45–08						
	SR_1	16–46–37						
	SR_2	(16–47–30)						
	eL	16–49	49	360				
	M_{1M}	16–53–08	25	412				
	M_{2M}	16–56·5	15	307				
	M_{3M}	17–04·7	13	84				
	M_{4M}	17–07	13	120				
	M_{5M}	17–10·5	13	90				
	M_{6M}	17–13·3	13	90				
	M_{7M}	17–22·3	13	85				
	L	17–25 to 20–05						
	F	20–30 ca						
1463								
May 4	O	(22–26–50)					(8100)	
	P?	22–28–20						
	S?	22–47–41						
	SR_2?	22–56						
	eL	23–01						
	L	23–10						
	L	0–40						
	F	1–15						
1464								
May 5	eL	9–57·5						
	F	10–04						

†M subscript indicates registration on Milne-Shaw seismographs only.

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1465 May 5	e	15-17-12						
	eL	15-23						
	L	15-27						
	F	16-00						
1466 May 8	e	19-23-00						Very faint traces only.
	eS?	19-27-22						
	eL?	19-32						
	L	19-34						
	L	19-46 to						
		20-07						
	F	20-18						
1467 May 10	e	4-01-32						Very small amplitudes.
	e	4-10-00						
	e	4-11-41						
	e	4-13-32						
	e	4-19-26						
	eL	4-47 to						
		5-04	19					
	F	6-20 ca						
1468 May 11	e?	(8-42-52)						
	e	8-44-00						
	e	8-49-37						
	e	8-54						
	L	9-20 to	35					
		9-38	19					
	F	10 ca						
1469 May 12	e	1-41-30						
	e	1-43-16						
	e	1-55						
	e	2-08						
	eL	2-22						
	L	2-29	44					
	L	2-40 to						
		2-59	22					
	L	3-02 to						
		3-27	21					
	F	4-00 ca						
1470 May 15	O	21-43-00					(7600)	
	P?	21-54-00						
	S?	22-03-00						
	eL?	22-09·5						
	L	22-20						
	L	22-23 to						
		22-50	16					
	L	22-51 to						
		23-05	16					
	F	23-35						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1471								
May 16	e	(18-27-28)						
	e	18-34-00						
	e	18-39·6						
	eL	19-04·5						Small sinusoidal L waves.
	L	19-11	19					
	L	19-19 to						
		19-43	16					
	F	20-00						
1472								
May 23	O	22-37-21					7580	
	P	24-48-20						
	S	22-57-19						
	eL	23-05-22						
	M_1	23-14						
	M_2	23-20·5	18					
	M_3	23-23·2	18					
	L	23-26 to						
May 24		0-06	15					
	L	0-06 to						
		2-06						
	F	2-45 ca						
1473								
May 25	e	22-45-45						On M-S No. 17 only.
	e?	22-52-15						
	eL	22-58						
	L	23-05	34					
	L	23-15	17					
May 26	F	0-00 ca						
1474								
May 26	O	3-29-41					4480	
	P	3-37-34						
	S	3-43-48						
	eL	3-49·5						
	L	4-00						
	L	4-07	21					
	F	4-55						
1475								
May 26	e	9-13·5						
	e	9-19						
	eL	9-35						
	L	9-41	30					
	L	9-54	20					
	F	10-45 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1476 May 28	eP_{17}?	1-48-45						
	eL	2-05-40						
	L	2-37	30					
	L	2-42	25					
	L	2-50 to						
		3-48	15					
	F	4-00 ca						
1477 May 30	eP_{17}?	8-48-23						
	eL	8-57						
	L	9-01						
	L	9-16						
	F	10-00						
1478 May 30	eL_{17}	16-02						
	L	16-11 to						
		16-18						
	F	16-25						
1479 May 30	i	18-14-30						
	L	18-25						
	L	18-27	15					
	L	18-36 to						
		19-01	15					
	F							Lost in changing sheets.
1480 May 31	e	6-19-52						
	e	6-26						
	eL	6-35						
	L	6-46 to						
		6-54	23					
	L	6-54 to						
		7-16	16					
	F	7-35						
1481 May 31	O	22-05-48					3380	
	P	22-12-19						
	S	22-17-28						
	eL	22-20						
	L	22-21·5 to						
		22-25	21					
	L	22-29 to						
		22-54	16					
	F	23-25						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1482 June 1	O	17–25–31					9320	
	P	17–38–00						
	PR_1	17–41–46						
	S	17–48–26						
	i	17–48–49						
	i	17–50–00						
	SR_1	17–54·5						
	L	18–09						
	L	18–14·5	23					
	M	18–19·5						
	M	18–24·5						
	M	18–28·5						
	L	18–30 to 20–00						
	F							Lost in next quake.
1483 June 1	P							Lost in preceding quake.
	S	20–39–23						
	L	20–46						
	L	20–55						
	L	21–02	23					
	M	21–13·5						
	L	21–20 to 22–40						
	F	23–26						
1484 June 2	e	1–20·5						
	e	1–28						
	eL	1–36						
	L	2–04						
	F	3–30 ca						
1485 June 2	eL	5–53·5						
	F	6–03						
1486 June 2	eL_M	13–39						On M-S only.
	L_M	13–43·5						
	F	14–26 ca						
1487 June 2	e?	14–43·7						
	e	14–54						
	L	15–14·5						
	F	16–00 ca						
1488 June 2	eL	23–58						
June 3	F	0–10 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1489								
June 3	eL	12–23						
	L	12–30·5						
	L	12–35 to						
		12–50						
	F	13–00 ca						
1490								
June 4	e?	(21–20)						Small traces only.
	eL	(21–40)						
	L	21–51 to						
		21–56						
	F	22–50 ca						
1491								
June 5	e	(6–26·0)						
	e	6–31·5						
	eL?	6–35						
	L	6–39 to						
		6–55						
	F	7–00 ca						
1492								
June 6	e	18–00–34						May be two quakes. Distant. Phases not marked. Strasbourg gives Δ=8880 km. and O=17-42-01.
	e	18–07						
	eL	18–16						
	L	18–29 to						
		19–12						
	L	19–40						
	L	20–07						
	L	20–29						
	F	20–55 ca						
1493								
June 6	e	23–10–23						Nearer than 1492 on same sheet.
	eL	23–14						
	M	23–15·5						
June 7	F	0–00 ca						
1494								
June 8	eL	8–16						Faint traces only.
	L	8–18 to						
		8–27						
	F	8–50 ca						
1495								
June 10	eL	1–46						Barely discernible.
	F	2–00 ca						
1496								
June 10	e	19–03·5						
	eL	19–10·5						
	L?	19–36						
	F	19–49						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1497 June 10	e?	20-38						Small traces only.
	e?	20-51·3						
	eL	20-57						
	L	21-00 to						
		21-23						
	F	21-40						
1498 June 11	e	11-30·4						
	eL	11-37 to						
		11-47						
	F	12-00 ca						
1499 June 12	eL	6-42						
	L	6-46 to						
		6-53						
	F	7-10						
1500 June 14	e	6-16-20						
	eL	6-19-45						
	F	6-49						
1501 June 18	O	8-26-16					4680	Strasbourg gives P=8-31-40 and Δ=7700 km.
	e?	8-31-00						
	P	8-34-23						
	S	8-40-48						
	i	8-41-41						
	SR_2	8-44-15						
	eL	8-50						Readings difficult to interpret accurately.
	L	9-06						
	L	9-12 to						
		9-33	20					
	L	9-34·5 to						
		10-50	13					
	F	11-35						
1502 June 18	e?	17-16						
	e?	17-20·8						
	eL	17-28·6						
	F	17-38						
1503 June 18	e	18-19·5						
	eL?	18-24						
	L	18-46 to						
		18-51						
	F	19-12 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1504								
June 19	O	22-43-32					4900	
	P	22-51-53						
	PR_1	22-53-38						
	S	22-58-30						
	i	23-01-02						
	SR_1	23-02-12						
	eL	23-06						
	M_1	23-07·5						
	M_2	23-10·5						
	L	23-14 to						
June 20		0-10						
	F	1-10 ca						
	HALIFAX	RECORD						
June 19	O	22-41-42					6450	
	P	22-51-39						
	S	22-59-39						
	L	23-10-40						
	M	23-14·5						
	F	Lost						
1505								
June 20	eL	6-28						
	F	6-44						
1506								
June 22	e	4-02						
	eL	4-05·4						
	L	4-08						
	F	4-38						
1507								
June 22	O	(6-54-19)					(6100)	
	P	(7-03-56)						
	S	7-11-37						
	SR_2?	7-17-06						
	eL	7-19-30						
	L	7-31						
	M	7-41·5						
	M	7-44·5						
	M	7-50						
	M	7-53·5						
	M	7-55·5						
	M	8-02						
	L	8-07 to						
		9-45						
	F	10-30						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1508								
June 22	e	(21-12-38)						
	e	(21-16-23)						
	eL	21-24						
	L	21-45	30					
	L	21-48	24					
	L	21-51 to						
		21-57	20					
	L	21-58 to						
		22-03	18					
	L	22-03 to						
		22-21	17					
	L	23-02						
	F	23-14						
1509								
June 24	eL	13-54						Very heavy micros.
	F							Lost in changing sheets.
1510								
June 24	eL	20-32						
	L	20-35						
	F							Micros.
1511								
June 25	eL	(13-15)						
	F							Lost in micros.
1512								
June 25	eL	22-14 to						
		22-23						
	F							Lost in micros.
1513								
June 26	eL	2-01						
	F	2-10 ca						
1514								
June 28	e?	19-04·3						
	eL	19-12						
	F	19-16						
1515								
June 30	eL	0-29·5						
	L	0-33						
	F	0-50 ca						
1516								
July 1	eL	8-49						
	L	8-55 to						
		9-11	18					
	F	9-33 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
1517		h m s	s	μ	μ	μ	km.	
July 2	e?	2-21·5						
	e?	2-39-04						
	e?	2-51-00						
	O	(2-45-49)					(7940)	
	eP?	2-57-07						
	eS?	3-06·4	9					
	eL?	3-21-30	43					The L waves are fairly sinusoidal, never great in amplitude, and taper off rapidly in amplitude after about 4-15.
	L	3-30	23					
	L	3-45	13					
	F	4-50						
1518								
July 2	e	16-59 to	14					
	F	17-10						
1519								
July 3	e	18-02-35 to						May not be seismic. On M-S only.
	F	18-11-15						
1520								
July 4	e?	5-42-30						Irregular faint trace of seismic origin.
	e	5-44-30 to						
	F	6-13						
1521								
July 4	O	(8-12-36)					(6180)	
	eP?	(8-22-17)						
	iS?	8-30-03						
	eL	8-39·5						
	L	8-45	15					
	L	9-20	10					
	F	9-55						
1522								
July 4	eL	23-55 to						Sinusoidal L waves of small amplitude.
July 5	L	0-05	18					
	F	0-20						
1523								
July 5	e	16-13 to						Faint traces on M-S only. Irregular.
	L	16-38						
1524								
July 6	e	6-06 to						Sinusoidal L waves. Very small. On M-S only.
	L	6-15	17					
1525								
July 7	e	6-24-45						
	e	6-29-40						
	L_{17}	6-40 to						
		6-45	14					
	F	7-05						
1526								
July 7	eL	13-40 to						Sinusoidal L waves of small amplitude. Beginning lost in changing the sheets.
	L	13-46	20					
	L	13-53 to						
		14-00	14					
	F	14-15						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1527 July 10	e?	0-41						
	iS?	0-50-32						
	eL?	1-00·5						
	L	1-25	13					
	L	1-45	12					
	L	2-08	12					
	L	2-31	12					
	L	3-06	12					
	F	3-30						
1528 July 10	$e?_{17}$	5-48						Very small amplitudes. On M-S No. 17 only.
	eL_{17}	6-00 to						
	L_{17}	6-10	15					
	F	6-25						
1529 July 12	O	(3-19-40)					(10340)	The emergence of P is very doubtful at the time shown, though it is evident a few seconds later. The agreement between the other phases, including LR_1 is extraordinarily good. The distance may prove a little greater than that given here.
	eP_{11}	(3-32-58)						
	i_{17}	3-34-44						
	iS_{17}	3-44-17						
	SR_1	3-50-37						
	eL_{17}	4-06·5						
	L	4-10 to						
		4-15	23					
	L	4-20 to						
		4-35	17					
	L	4-50 to						
		5-10	15					
	L	5-15	15					
	LR_1	5-27	21					
	L	5-33 to						
		5-42	16					
	F	6-10 ca						
1530 July 12	e_{17}	9-42-07						
	$eS?_{17}$	9-48-40						
	eL_{17}	10-06	32					
	L	10-13	21					
	L_{17}	10-17	16					
	L_{17}	10-29	14					
	L_{17}	10-40	14					
	F	11-05						
1531 July 13	O	11-14-45					9520	The maximum was recorded with about the same period and amplitude, and at about the same time on all three types of seismograph of quite different constants. Agreement very good for Δ.
	P	11-27-24						
	PR_1	11-31-25						
	S	11-38-00						
	eL	11-58-00						
	L	12-06	29					
	M	12-16	17	60				
	L	12-30	17					
	L	13-00	15					
	F							Lost in changing sheets at about 13-30.

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1532								
July 13	e_{17}	16-47-40						
	eL_{17}	16-57 to						
		17-09	16					
	F	17-12						
1533								
July 14	e	0-20-40						
	e	0-30-40						
	eL	0-42	32					
	L	0-51	25					
	L	0-59	18					
	L	1-13	16					
	L	1-26	16					
	L	1-42	12					
	F	2-00 ca						
1534								
July 16	e_{17}	13-58-36						
	i_{17}	14-04-15						
	i_{17}	14-05-36						
	i_{17}	14-08-29						
	i_{17}	14-10-20						
	$eS?_{17}$	14-14-58						
	eL?	14-36						L waves distinctly sinusoidal but of very small amplitude. Preliminary phase indications on M-S only.
	L	14-38 to	23					
		15-00	15					
	L	15-10	15					
	L	15-56	17					
	F	16-30						
1535								
July 17	e?	1-10-15						
	e	1-16-43						
	e	1-20-00						
	eL?	1-23·6 to						Irregular L waves of small amplitude.
		1-33						
	F	1-38						
1536								
July 18	O	1-05-55					3600	Small record but very good agreement.
	P	1-12-43						
	S	1-18-07						
	eL	1-22 to	29					
		1-27	15					
	F	2-00 ca						
1537								
July 18	O	6-02-13					3580	Undoubtedly from the same epicentre as No. 1536. The very characteristics of each phase are the same. A remarkable pair of records in the experience of this station.
	P	6-09-00						
	S	6-14-22						
	eL	6-18·5 to	29					
		6-28	15					
	F	7-00						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1538								
July 20	i	5-06-00						Very small traces of L waves on M-S
	eL	5-20 to						only.
	F	5-45						
1539								
July 20	e	15-14-00						On M-S only. Wireless from Stras-
	i	15-23-45						bourg gives P =15-12-00 Δ =6000
	eL	15-31						
	L	15-36	28					
	L	15-47	16					
	L	16-05	14					M-S No. 23 not recording after
	F	16-52 ca						July 20.
1540								
July 21	eL	14-13·5						
	L	14-21 to						
		14-30	13					
	L	14-40						
	F	14-45						
1541								
July 22	O	14-18-07					7320	Long continued appearance of L
	P	14-28-52						waves, quite sinusoidal, but of
	S	14-37-40						small amplitude.
	SR_1	14-45·5						
	eL	14-51						
	L	15-06	13					
	L	15-35	12					
	F	17-00 ca						
1542								
July 23	e?	7-38-10						Irregular L waves of small amplitude
	e	7-48-00 to						and short period.
		7-55						
	F	8-10						
1543								
July 26	eL	(8-10) to	23					Sinusoidal L waves only. Time
		(8-40)	15					marks uncertain.
	F	(9-00)						
1544								
July 26	eL	(10-50) to	30					Sinusoidal L waves only. Time
		(11-15)	15					marks uncertain.
	F	(11-50)						
1545								
July 30	eL	23-53 to	20					M-S only.
July 31		0-05	10					
	F	0-10						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1546 July 31	i	5-53-59						
	i	5-54-48						
	e	5-59						
	L	6-01	9					
	F	6-20						
1547 July 31	e	15-23-00						
	e	15-27-30						
	e	15-39-50						
	e	15-41-10						
	eL	15-42 to	17					
		16-18	10					
	F	17-15						
1548 Aug. 1	eL	5-24						No. 17 only.
		5-34	20					
	L	5-55	16					
	L	6-30	16					
	F	7-00						
1549 Aug. 1	i	8-37-20						Very slight traces which are probably not seismic appear at 8-28.
	i	8-37-47						
	eL	8-53	14					
	F	9-15						
1550 Aug. 2	e	9-45-24						
	eL	9-48·2	10					
	L	9-52	6					
	F	9-55						
1551 Aug. 4	eL	17-13 to	20					Small sinusoidal L waves on No. 17 only.
		17-55	10					
	F	18-00						
1552 Aug. 8	eL	9-05						No. 17 only.
	F	9-23						
1553 Aug. 8	e	11-04 to						Very short periods, small amplitudes, L waves (?).
		11-15	5					
	F	11-18						
1554 Aug. 8	O	(12-01-48)					(3500)	
	iP?	12-08-28						
	i	12-09-51						
	eS?	12-13-45						
	eL	12-16·5						
	L	12-24	14					
	F							Lost in succeeding quake.

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1555								
Aug. 8	eP?$_V$	12-27-39						There is no doubt that there are two distinct quakes here in 1554 and 1555. The P wave of 1555 is lost in the coda of 1554 in all records except the vertical.
	e	12-35·8						
	eL$_{17}$?	12-42·7						
	L$_{17}$	12-45·6	30					
	L$_{17}$	12-51	16					
	F	13-50 ca						
1556								
Aug. 10	L	3-08 to						No. 17 only.
	F	3-18						
1557								
Aug. 10	eL	16-45	25					Sinusoidal L waves on No. 17 only. Micros heavy.
	L	16-55	30					
	L	17-05	25					
	F	17-20						
1558								
Aug. 10	eL	23-08						Sinusoidal L waves. No. 17. Heavy micros.
	L	23-15 to	27					
		23-45	15					
Aug. 11	F	0-10						
1559								
Aug. 11	e	1-27·7						Sinusoidal L waves. No. 17. Heavy micros.
	i	1-38						
	eL?	1-51·5	40					
	L	1-59	26					
	L	2-05	23					
	L	2-20	16					
	L	2-38	13					
	F	3-15						
1560								
Aug. 12	e?	6-55						No. 17 only.
	e	7-04 to						
		7-12						
	L	7-13 to						
		7-28	14					
	F	7-35						
1561								
Aug. 12	e?	10-24-46						
	e	10-25·2						
	eL?	10-54						
	L	11-01·5 to	28					
		11-35	12					
	F	12-00 ca						
1562								
Aug. 12	eL	17-42 to	14					
	F	18-00						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1563								
Aug. 16	e	20-44-40						Sinusoidal L waves. Record on
	e?	20-53·8						No. 17 only. Small amplitude.
	eL	21-03	22					
	L	21-12	20					
	L	21-20						
	F	22-00 ca						
1564								
Aug. 17	i	1-25-31						No. 17 only. Sinusoidal L waves of
	e	1-24						small amplitude.
	eL	1-45·5	18					
	F	2-15						
1565								
Aug. 17	eL	4-27 to	20					No. 17 only.
	F	5-00 ca						
1566								
Aug. 17	L	12-14 to						No. 17 only.
		13-10	20					
	F							Lost in changing sheets.
1567								
Aug. 19	e	12-56·5						No. 17 only.
	i	13-01-28						
	eL?	13-18·5						
	L	13-25	24	6				
	L	13-35	18					
	L	13-46	16					
	F	14-15						
1568								
Aug. 20	L	19-20 to	20	1				
	F	20-10						
1569								
Aug. 23	O	(5-21-31)					(5060)	
	eP	5-30-03						Only traces on Bosch instruments.
	eS	(5-36·8)						
	eL	5-42·9	18	6				
	L	5-51	14					
	F	7-00 ca						
1570								
Aug. 26	L	(14-30)	22	1·5				Small sinusoidal waves. L easily read
	F	(15-15)						but time marks uncertain.
1571								
Aug. 28	O	23-15-17					3470	
	iP	23-21-55						
	iS	23-27-10						
	eL	23-31						
	M	23-34	(8)	(307)				Period at M may have been greater
	L	23-49	14	58				than 8 seconds as it was difficult
Aug. 29	L	0-18	11	8				to determine.
	L	0-50	11	1				
	F	2-00 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1572								
Aug. 30	L	(15-00)	18	1				Time marks uncertain. No. 17 only record.
	F	(15-45)						
1573								
Sept. 1	O	2-58-59					9760	
	eP	3-11-49						
	iS	3-22-36						
	eL	3-37	(60)					
	M	3-53·5	20	381				
	L	4-03	17	171				
	L	4-30	16	71				
	L	4-54	14	37				
	L	5-16	14	16				
	L	5-48	14	9				
	L	6-05	13					
	L	6-40	13					
	L	7-05						
	eL	8-20						
	L	8-25	28	15				
	L	8-34	19	9				
	L	8-50	13					
	F	9-50						
	SASKATOON RECORD							
	O	2-58-35					8520	Good record on both horizontal components.
	P	3-10-25						
	S	3-20-09						
	eL	3-31·5 ca						
	HALIFAX RECORD							
	O	2-58-55					10050	
	P	3-12-00						
	PR_1	3-15-50						
	S	3-23-00						
	SR_1?	3-29-18						
	eL	3-42-30						
1574								
Sept. 2	O	2-47-11					9560	
	P	2-59-52						
	PR_1	3-03-49						
	S	3-10-30						
	i	3-12-17						
	SR_1	3-17-30						
	eL	3-32						
	M	3-48	19	247				
	F	7-00						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1575								
Sept. 2	O	(9–24·1)					(9900)	Time marks failed on all seismographs.
	P	(9–37·0)						
	PR_1	(9–40·7)						
	S	(9–47·9)						
	SR_1	(9–54·2)						
	SR_2	(9–58·3)						
	eL	(10–04)						
	M	(10–22)						
	F	(12–30)						
1576								
Sept. 2	e	13–51						M-S only.
	eL	13–57						
	L	14–02 to						
		14–07						
	F	14–30 ca						
1577								
Sept. 2	e	15–06·7						
	L	15–10						
	F	15–21 ca						
1578								
Sept. 2	O	(22–38·6)					6340	Time marks uncertain.
	P	(22–48·5)						
	S	(22–56·4)						
	SR_1?	(23–01·7)						
	eL	(23–05)						
	M	(23–09)	Irreg.					
Sept. 3	F	1–10 ca						
1579								
Sept. 9	O	4–18–18						Very faintly defined.
	P	4–25–52					4220	
	S	4–31–52						
	eL	4–36–30						
	F	5–05						
1580								
Sept. 9	eL	18–03·7						Faint traces on M-S only.
	L	18–08						
	F	18–15						
1581								
Sept. 9	O	(22–13–17)					(5960)	
	P	(22–22–45)						
	S	22–30–19						
	eL	22–38–08						
	M	23–00	34					
	L	23–04	(26)					
	L	23–18	(16)					
Sept. 10	F	1–20						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1582 Sept. 10	e?	9–51·5						
	eL	9–54						
	L	9–59						
	F	10–27 ca						
1583 Sept. 10	e?	12–52·5						
	eL	12–55						
	F	13–05						
1584 Sept. 11	e	9–15–52						
	iS?	9–20–08						
	eL	9–24						
	L	9–27						
	F	9–55 ca						
1585 Sept. 12	e?	(6–14)						Time marks uncertain.
	i	(6–20·5)						
	e	(6–23)						Slight traces. Only on M-S.
	L	6–55	15					
	F	7–25						
1586 Sept. 14	e							Lost in changing sheets.
	eL	13–48 to	15					
	F	14–10						
1587 Sept. 16	e?	16–55–17						M-S record only.
	i	16–55–59						
	e	17–02–40						
	e	17–07–27						
	e	17–13–40						
	eL	17–36·7						Sinusoidal L waves.
	L	17–42	19	8				
	L	18–01	15					
	L	18–44	18					
	F	19–25						
1588 Sept. 17	e?	4–03–10						Faint traces only. M-S.
	e	4–11–24						
	eL?	4–24						
	L	4–32						
	F	4–50						
1589 Sept. 17	i	7–32–45						Sinusoidal L waves.
	eL	7–45						
	M	7–52	28	12				
	L	8–01	15	8				
	L	8–20	12					
	F	9–00 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1590 Sept. 18	L	4–38 to						Faint sinusoidal L waves on M-S only.
	F	4–40						
1591 Sept. 19	e	8–39 to						Irregular faint traces on M-S only.
	F	8–52						
1592 Sept. 19	e	19–47 to						Faint traces only.
	F	19–58						
1593 Sept. 20	e	9–33 to						Irregular faint traces only.
	F	9–49						
1594 Sept. 20	eL	(16–00)						Faint sinusoidal L waves. M-S only. Time uncertain.
	F	(16–02)						
1595 Sept. 21	e?	20–24–15						No. 17 only.
	eL	20–49 to						Faint sinusoidal L waves.
		20–54	16	1				
	L	21–00 to	14					
		21–06						
	F	21–15						
1596 Sept. 22	e	(12–47)						
	i	12–50·5						
	F	13–10						
1597 Sept. 22	eL	15–50 to	23					
		16–25	17					Small amplitude—less than 1μ.
	F	16–35						
1598 Sept. 22	P?	21–04–20						
	e	21–11·4						
	i	21–15–28						
	eL?	21–26						
	L	21–29	50	70				
	L	21–45	17	21				
	L	22–04	14	3				
	L	23–05	18					Very small trace at 23–05.
Sept. 23	F	0–00 ca						
1599 Sept. 23	eL	4–04 to	9					Regular faint traces of small amplitude and short period.
	F	4–30						
1600 Sept. 23	i	17–44–08						
	e	17–47·8						
	eL?	17–52·7						
	M	17–57·5	11	6				
	L	18–10	10					
	F	18–35						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1601 Sept. 23	e	21–31·5						No. 17 only.
	eL	21–35·6						
	F	21–52						
1602 Sept. 24	eL	16–11						Faint sinusoidal trace.
	F	16–13						
1603 Sept. 26	e?	(2–43)						Time marks uncertain throughout. No definite phase markings.
	i	(2–47·7)						
	eL	(2–54·3)						
	L	3–10	13					
	F	3–50						
1604 Sept. 26	e	8–48·2						No definite phases shown.
	eL?	9–05						
	L	9–11						
	M	9–19	20					
	L	9–26	14					
	L	9–43	14					
	L	10–03	14					
	F	10–40 ca						
1605 Sept. 27	e	(7–36·8)						On M-S only. Faint traces. Sinusoidal L waves.
	eL?	(7–41·6)						
	L	8–05	16					
	L	8–25	16					
	F	9–00 ca						
1606 Sept. 28	e	21–15–10						Except for about five minutes at the maximum, the record is a faint trace of irregular wavelets.
	eL	21–18–50						
	M	21–23	Irreg.					
	F	22–05						
1607 Sept. 29	eL	7–46 to						Very faint sinusoidal trace on No. 17 only.
	F	7–58						
1608 Sept. 30	O	1–20–56					3040	
	P	1–26–56						
	S	1–31–42						
	eL?	1–34 ca						
	M_{17}	1–40	12	300				
	L	1–50	10					
	L	2–17	10					
	L	2–44	10					
	L	3–17	11					
	L	4–45	18					
	L	5–12	10					
	L	5–30 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1609								
Oct. 1	e?	8-55						
	eL	9-04	30					
	L	9-13	19					
	L	9-19	16					
	F	9-48						
1610								
Oct. 1	O	22-40-21					10040	Well-marked phases.
	P	22-53-25						Very small amplitudes.
	S	23-04-25						
	eL	23-24	31	5				
	L	23-33	16					
	L	23-43	15					
Oct. 2	F	0-10						
1611								
Oct. 3	eL	16-35						
	L	16-42	18					
	F	16-55						
1612								
Oct. 4	i	17-50-40						Irregular traces preceded by a sharp impulse.
	L	18-03						
	F	18-25						
1613								
Oct. 7	O	(3-26-06)					(12140)	
	eP	3-51-09						
	S	(4-03-35)						
	e	4-08·5						
	e_1	4-13·8						
	eL_1	4-31						Sinusoidal L waves.
	M	4-43	19	70				
	L	4-50	19	30				
	L	5-13	16					
	L	5-35	16					
	L	6-02	15					
	L	6-35	13					
	F	7-10						
1614								
Oct. 8	O	3-52-28					1570	
	eP	3-55-49						
	eS	3-58-33						
	eL	3-59·5						
	M	4-03	21	7				
	L	4-06	13					Very faint L waves after 4-06.
	F	4-50						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1615								
Oct. 10	O	7-11-08					4460	
	iP	7-18-59						
	iPR$_1$	7-20-30						
	iS	7-25-12						
	SR$_1$	(7-28·4)						
	SR$_2$	(7-29·2)						
	eL$_{II}$	7-31·5						
	M$_{17}$	7-33	17	45				
	L$_{17}$	7-42	9	10				
	L	7-55	Irreg.	Small				
	F	9-00 ca						
1616								
Oct. 10	e	23-06 to						Faint traces of L waves on M-S only.
	F	23-30						
1617								
Oct. 11	e	12-41·5						
	eL?	12-45	16					Small sinusoidal L waves.
	L	12-52	13					
	L	13-00	13	1				
	F	13-25						
1618								
Oct. 13	e	4-41·3						
	eL	4-46						
	M	4-48	12	13				
	L	5-01	7					
	F	5-30						
1619								
Oct. 15	e	(8-25)						Horizontal slit on M-S was partially obscured by a bit of lint at light spot. No definite record.
	eL?	(8-48)						
	L	9-15	19					
	L	9-33	16					
	L	10-00	16					
	F	10-15 ca						
1620								
Oct. 15	eL	20-45						Faint sinusoidal L waves.
	L	20-46	12	1				
	E	20-55						
1621								
Oct. 17	e	6-54 to						Irregular faint traces. M-S.
	F	7-08						
1622								
Oct. 18	eL	22-13						
	L	22-18	20					Sinusoidal L waves.
	F	22-25						
1623								
Oct. 20	eL	4-06	30					Irregular to sinusoidal L waves.
	L	4-22	16					
	L	4-30	14					
	F	4-40						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1624								
Oct. 21	e	19-16-38						Irregular small wavelets.
	F	19-35						
1625								
Oct. 22	e	16-22·8						Faint trace, M-S only. Lost in
	F	16-33						micros.
1626								
Oct. 26	e	19-39 to						
	F	19-49						Irregular faint traces on M-S only.
1627								
Nov. 1	e	20-16-06						New Zealand paper reports this
	eL	20-16-37						quake as being observed by Adams
	M	20-17·9	12	12				at Wellington, N.Z., in adjusting a
	L	20-20	7	2·5				transit. The level bubble indicated
	L	20-27	7	1				the L waves.
	F	20-58						
1628								
Nov. 2	O	21-14-32					(10040)	Difficult record to read. eS un-
	P_v	21-27-36						certain as well as the correct
	eP	(21-28-24)						reading for P.
	PR_1	(21-32-09)						
	PR_2	21-34-24						
	eS	(21-38-36)						
	SR_1	21-44-52						
	SR_2	21-49-11						
	eL	21-58-30						
	M_1	22-19·5	18	72				
	M_2	22-25·7	17	63				
	M_3	22-28·5	17	50				
	M_4	22-30	17	63				
	L	22-33	17					
	L	22-39·5	17					
	L	23-07	24					
	L	23-16						
Nov. 3	L	0-30						
	F	1-00 ca						
1629								
Nov. 3	eL	3-41						Sinusoidal L waves
	L	3-48	20	0·5				
	F	4-02						
1630								
Nov. 3	e?	5-43						Sinusoidal L waves.
	eL	5-52·5	22					
	L	6-03·5	20	2·5				
	L	6-16	15					
	F	7-05						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
1631		h m s	s	μ	μ	μ	km.	
Nov. 3	O	8-37-43					2820	
	P	8-43-22						
	S	8-47-52						
	eL	8-50-00						
	M	8-53	20					
	L	8-56	16					
	L	9-03	12					
	L	10-07						
	L	10-25						
	F	10-35 ca						
1632								
Nov. 3	e	16-44-28						
	eS?	16-56-00						
	eL	17-05						
	M_1	17-13	30	30				
	M_2	17-19	20	20				
	L	17-22·5	15					
	L	17-34	15					
	L	18-20						
	F							Lost in micros.
1633								
Nov. 4	O	0-12-41					9000	
	P	0-24-54						
	PR_2	0-30-12						
	e	0-31-49						
	S	0-35-04						
	SR_1	0-41-24						
	SR_2	0-45-28						
	eL	0-55						
	M_1	1-08·6	22	89				
	M_2	1-10·5	22	90				
	L	1-17	19					
	L	1-31	15					
	L	2-07	15					
	L	2-17	15					
	L	3-00						
	F							
1634								
Nov. 4	eL	12-53 to						
	F	13-15						Lost in micros.
1635								
Nov. 4	e	20-33·5						
	e	20-40-56						
	e	20-49-15						
	eL	21-01-45						
	L	21-06	26					
	M	21-10	20	6				
	L	21-22	20					
	L	21-38	16					
	F	22-22 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1636 Nov. 4	eL	23–15						
	L	23–24	20					
	F	23–45						
1637 Nov. 5	L	2–23	22					
	F	2–37						
1638 Nov. 5	eL	14–37						
	L	14–39	29					
	L	14–42	16					
	F	14–55						
1639 Nov. 5	O	21–29–07					10140	
	P	21–42–16						
	PR_1	21–46–13						
	PR_{21}	(21–48–18)						
	S	21–53–20						
	i	21–55–15						
	SR_{21}	22–04·5						
	eL	22–13						
	M_1	22–16·0	44	105				
	M_2	22–22·4	28	50				
	M_3	22–27·5	24	35				
	L	22–35·5	16					
	L	23–09 to 23–55	16					
Nov. 6	F	1–00 ca						
1640 Nov. 6	i	17–38–08						On M-S only.
	L	17–53	36					
	L	18–00	20					
	F	19–35 ca						
1641 Nov. 6	e	(20–00)						
	eL	20–09	36					
	L	20–20·5	16					
	F	21–12 ca						
1642 Nov. 7	i	14–14–26						
	L	14–30						
	L	14–40	40					
	L	14–47						
	F							Lost in changing sheets.
1643 Nov. 8	O	0–01–48					3600	
	P	0–08–36						
	S	0–14–00						
	SR_1?	0–15–26						
	eL	0–17–00	8	11				
	F	1–05 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1644 Nov. 8	e	20-45·5						Sinusoidal L waves on M-S No. 17 only.
	eL	20-53						
	L	20-56·5	20					
	F	21-15 ca						
1645 Nov. 9	O	3-22-43					2880	
	P	3-28-28						
	S	3-33-02						
	eL	3-35-39						
	L	3-38						
	L	3-40	35	7				
	L	3-45						
	F	4-45 ca						
1646 Nov. 10	e	4-38						
	eL	4-43						
	F	5-12 ca						
1647 Nov. 10	eL?	22-00						
	L	22-22	20					
	L	22-28	18					
	L	22-35	16					
	L	22-59	12					
	F	23-05						
1648 Nov. 11	e?	6-05						May not be seismic.
	e	6-12						
	F	6-15						
1649 Nov. 11	e	14-18						
	eL	14-21	30					
	L	14-26	Irreg.					
	F	14-40						
1650 Nov. 12	O	(11-56-21)					(3580)	Identification of the phases recorded is doubtful.
	P?	12-03-08						
	S?	12-08-30						
	SR_2?	12-10-38						
	eL?	12-13						
	L	12-20	30	5				
	L	12-26	15					
	F	13-10 ca						
1651 Nov. 16	O	(4-15-22)					(4120)	
	P?	4-22-49						
	S	4-28-43						
	eL	4-33·5						
	M_1	4-35·5	11	41				
	M_2	4-38	10	21				
	L	4-47	10					
	L	4-56	15					
	F	5-25 ca						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1652 Nov. 16	eL	7-26·3						
	L	7-27-15	12					
	L	7-29-34	8					
	F							Micros obscure the exact time of F.
1652A Nov. 16	eL	19-26						Faint traces only of sinusoidal L waves on M-S No. 17.
	L	19-30	20					
	L	19-48·5						
	F							Lost in micros.
1653 Nov. 17	O	2-52-49					7120	
	P	3-03-23						
	PR_2	3-07-24						
	S	3-11-58						
	SR_1	3-16-46						
	SR_2	3-18-57						
	eL	3-22	40	5				
	M	3-32·5	16	14				
	L	3-39	16	3				
	L	3-46	16					
	F	5-10 ca						
1654 Nov. 18	e	(21-48·3)						
	S?	21-57-39						
	SR_1?	22-03-12						
	eL	22-12						
	L	22-18·5						
	L	22-27	20	3				
	L	22-38·5						
	L	22-45	15					
	F	23-35						
1655 Nov. 19	eL	9-13·5						
	L	9-17·3 to 9-30						
	F							Lost in micros.
1656 Nov. 22	eL	8-19						Sinusoidal L waves.
	L	8-28	18	1				
	L	8-33						
	F	8-45						
1656A Nov. 23	e	3-22						
	L	3-28	24					
	F	3-45 ca						
1657 Nov. 25	eL	(17-50)						Time marks failed. Time approximate.
	L	(17-55)	38					
	L	(17-59)	30					
	L	(18-06)	15					
	F	(18-40)						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1658								
Nov. 26	e	(13–05)						Time marks failed. Time approximate.
	L	(13–26)						
	M	(13–37)	24	5				
	L	(14–07)	24					
	F	(14–34)						
1659								
Nov. 26	e	16–26–00						
	eL	16–32						
	F	16–42 ca						
1660								
Nov. 28	e?	0–40						
	eL	0–49	15					Sinusoidal L waves—small.
	F	1–00 ca						
1661								
Dec. 2	e	15–13·8						M-S No. 17 only.
	L	15–40	19	5				Sinusoidal L waves.
	L	16–00	16					
	F	17–00 ca						
1662								
Dec. 3	eL	8–56						M-S No. 17 only.
	L	8–59	19	1·5				Sinusoidal L waves.
	F	9–15						
1663								
Dec. 5	O	20–56–56					7640	
	iP_{17}	21–07–58						
	iS_{17}	21–17–00						
	eL	21–28·0	23	4·5				V_L is very high—nearly 245 km/m. on an average.
	M	21–39	15	7				
	L	21–43	13	1				
	LR_1?	23–16	Irreg.					
	F							Lost in what is recorded as 1664 but which may be the LR_1 of 1663.
1664								
Dec. 5	eL?	23–18	Irreg.					Sinusoidal L waves. Some micros.
	L	23–39	37	8				
	L	23–57	25	3·5				
Dec. 6	L	0–09	16	1				
	F	0–50ca						
1665								
Dec. 7	eL_{17}	(16–30)						
	L_{17}	16–32 to	Irreg.					
	F	16–40						
1666								
Dec. 11	eL_{17}	6–11	28					
	L_{17}	6–16	23	1·5				
	L_{17}	6–24	16	1				
	L_{17}	6–33	14					
	F	6–50						

TABULAR LIST OF EARTHQUAKES—*Continued*

No. and Date	Phase	Time	Period	Amplitude A_E	Amplitude A_N	Amplitude A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1667 Dec. 13	e_{17}	17-05-06						Micros mask the record a good deal.
	e_{17}	17-07·6						
	eL_{17}	17-11						
	L_{17}	17-12	Irreg.					
	F	17-25						
1668 Dec. 14	O	(10-42-23)					(1820)	Time marks somewhat blurred. Time uncertain.
	iP_{17}	10-46-15						
	iS_{17}	(10-49-22)						Strasbourg reports a quake by wireless. No trace of this appears on our records. Strasbourg P = 16-01-32, Δ = 117 km.—Dec. 14.
	eL	(10-50)						
	M	10-58·5	23	9				
	L_{17}	11-08	10					
	F	11-45 ca						
1669 Dec. 15	eL	12-52 to	Irreg.					Small L waves lost in micros.
	F	13-05						
1670 Dec. 16	O	7-36-48						
	eP_{17}	7-45-03						
	eS_{17}	7-51-34						
	$eSR_{1\ 17}$	7-54·6						
	eL	(7-58)						Irregular L waves less than a micron in amplitude.
	F	8-20						
1671 Dec. 19	eL	20-14·5	(20)					Sinusoidal L waves lost in heavy micros.
	F	20-20						
1672 Dec. 22	O	(9-59-38)					(2940)	
	eP	(10-05-27)						
	eS	10-10-06						
	eL	10-13-00	40	23				
	L	10-21	18	14				
	L	10-25	14	6				
	F	11-10 ca						
1673 Dec. 22	eL	18-15						Faint trace of sinusoidal L waves in micros.
	F	18-24						
1674 Dec. 26	i	8-09-52						
	e	8-10-50						
	e	8-12-22						
	eL	8-16-32						
	L	8-19-18						
	F	8-30						

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TABULAR LIST OF EARTHQUAKES—*Concluded*

No. and Date	Phase	Time	Period	Amplitude A_E	A_N	A_Z	Distance	Remarks
		h m s	s	μ	μ	μ	km.	
1675 Dec. 27	e	15-03						Micros mask preliminary phases.
	e	15-09·4						
	eL	15-28	26	4				
	L	15-38	20	3				
	F	15-45						
1676 Dec. 28	eL	23-07						Micros mask much.
	L	23-15	22	4				
	L	23-26	13	1				
	F	23-45 ca						

CONSTANTS OF THE SEISMOGRAPHS

=45° 23′ 38″ N. λ=75° 42′ 57″ W. h=83m.

Lithologic foundation: boulder clay over limestone (Ordovician). Time: Mean Greenwich, midnight to midnight. Time correction: within .25s.

INSTRUMENTS—FIXED CONSTANTS

Instrument	Symbol	Registration	Damping	Paper Speed	Mass
Bosch	I	Photographic	Air	15 mm. per min.	200 g.
Bosch	II	Photographic	Magnetic	15 mm. per min.	200 g.
Milne Shaw	17	Photographic	Magnetic	8 mm. per min.	1 lb.
Milne-Shaw	23	Photographic	Magnetic	8 mm. per min.	1 lb.
Deformation	D	Photographic	Air	17 mm. per min.	20 g. ca.
Spindler-Hoyer	W	Smoked Sheet	Air	15 mm. per min.	80 kgm.

INSTRUMENTS—DETERMINED CONSTANTS

SEISMOGRAPH I

Determined	T_o	V	ϵ	Comp.	Remarks
December, 1922	5·5	120	2:1	N-S	
February 7, 1923	5·5	120	2:1	N-S	
April 4, 1923	5·5	120	2:1	N-S	

INSTRUMENTS—DETERMINED CONSTANTS—*Continued*

SEISMOGRAPH II

Determined	T_0	V	ϵ	Comp.	Remarks
December, 1922	6·5	120	aper.	E-W	High period and strong damping were found to result in a badly defined zero. Hence the reduction of both.
February 7, 1923	6·5	120	18:1	E-W	
April 4, 1923	5·8	120	18:1	E-W	
May 3, 1923	5·3	120	18:1	E-W	
May 30, 1923	5·3	120	18:1	E-W	
August 21, 1923	5·4	120	15:1	E-W	

SEISMOGRAPH 17

December, 1922	12·0	250	20:1	E-W	
February 7, 1923	12·0	250	20:1	E-W	
April 4, 1923	12·0	250	20:1	E-W	
May 3, 1923	12·0	250	20:1	E-W	1″ tilt = 44·5 mm. displacement.
May 30, 1923	12·0	250	20:1	E-W	
August 21, 1923	12·0	250	20:1	E-W	

SEISMOGRAPH 23

December, 1922	12·0	250	20:1	E-W	In parallel with 17.
February 7, 1923	12·0	250	20:1	E-W	" 17.
March 9, 1923	12·0	250	15:1	E-W	" 17.
March 17, 1923	12·0	250	10:1	E-W	" 17.
April 4, 1923	12·0	250	10:1	E-W	" 17.
May 3, 1923	12·0	250	5:1	E-W	1″ tilt = 42·0 mm. displacement.
May 30, 1923	12·0	250	20:1	E-W	
July 21, 1923	12·0	250	20:1	E-W	At Shirley bay, Ont.
October 21, 1923	12·0	250	20:1	E-W	At Kemptville, Ont.
November 25, 1923					Out of service for rest of year.

SEISMOGRAPH W

December, 1922	6·0	160	20:1	Vert.	
February 7, 1923	6·0	160	20:1	Vert.	r = ·6 mm.
April 4, 1923	6·0	160	20:1	Vert.	r = ·6 mm.
May 3, 1923	6·0	160	20:1	Vert.	r = ·6 mm.
May 30, 1923	6·0	160	20:1	Vert.	r = ·6 mm.
August 22, 1923	5·5	160	4:1	Vert.	

The Deformation instrument was tested as to periods only with the following results. Numbers are values for T_0

	Determined for D_1(E-W)	Determined for D_2(N-S)
December, 1922	37.2	36.1
February 7, 1923	37.2	36.1

The time as recorded on the seismograph sheets is correct to within ±.25 sec.

As the time is impressed on the record line itself there are no corrections for parallax to be applied.

MICROSEISMS

During the year the microseisms were read four times each day, on both components. The periods and trace amplitudes were tabulated. The reductions of the trace amplitudes to true earth movement were not made. The tabulated values were not reported on in our bulletins, nor are they compiled for this report but they are on record here if desired. A notable microseism storm occurred on November 19-20, 1923. The records at Ottawa indicated a true earth movement (half-amplitude) of 6.5μ with a period of 7 sec.

EXPERIMENTAL WORK WITH THE MILNE-SHAW SEISMOGRAPHS

Milne-Shaw seismograph No. 17 was received in December, 1921, and records from it have been obtained regularly since June, 1922. In October, 1922, Milne-Shaw seismograph No. 23 arrived. It was placed in operation early in 1923 and on March 9 experimental work was begun with this instrument. It was first set up side by side with No. 17, of which it is the counterpart. Set on the same pier, with the same constants, and recording the same component, the records were practically identical for a number of earthquakes, some of them large ones.

The conditions were then kept constant except for the variation in the damping ratio. This was changed for No. 23 from 20:1 to 15:1 and later to 10:1 and then 5:1. Each time the instrument was kept long enough with the given damping ratio to get several earthquakes recorded both on No. 23 and on No. 17. It was found that the damping ratio began to seriously affect the record when set at 10:1 and that the seismograph was practically useless at 5:1 for the damping ratio. The records seemed to be practically identical when No. 17 was set at 20:1 and No. 23 at 15:1.

This series of experiments was interrupted to take No. 23 out to Shirley bay, Ont.—about eight miles approximately west of the Observatory. Here it was given the standard constants of No. 17 which remained in the vault at Ottawa. The magnification was set at 250 fold; the damping ratio was made 20:1; the undamped period adjusted to 12.0 sec. It was mounted to record the E-W component, in the same way as the Ottawa instrument, *i.e.* with the pillar at the south edge of the pier.

Shirley bay is a cove in the south bank of Ottawa river, near the Connaught Rifle Ranges. The shore is rocky and the soil a few feet inland is very shallow. A small grove of poplar is the only natural shelter. These are young trees a few inches in diameter. To the north of the site chosen, lake Deschenes, an expansion of the Ottawa, stretches, unbroken by islands, for a width of over two miles. It was found later that this was a distinct disadvantage as the winds off the lake were practically constant.

The seismograph was mounted on a cement pier, 6 feet long by 3 feet wide, built into the ground and about a huge boulder resting on the rock. The pier projected only about eight inches above the surface, and was sheltered by a tent. A cook tent, sleeping tent and an instrument tent were also pitched. A wireless mast, 55 feet high was rigged by Mr. J. P. Henderson, in charge of the observatory wireless work. Mr. Henderson's efforts to assist in the work of the station by giving wireless time service from the observatory were indefatigable. Sending and receiving apparatus enabled the operator to communicate with the home station. The signals were sent out from the sidereal clock, two or three times a day. The same signals were impressed on the records at the observatory as were transmitted to Shirley bay and impressed on the records there. The different human link at each end would not, in all probability, cause an error on any sheet of more than half a second. Averaged over the whole time the time recorded would be comparable at will to a much closer approximation than that—well within the possibility of reading time on the record. A good box chronometer with a very even rate of about a second a day was used to impress the time on the seismograph sheet. When the sidereal check signals came in they were tapped with a telegraph key into the same electric circuit, superimposing the check times on the ordinary mean time signals, or, by throwing a switch, the mean time signals could be cut off while the others were being impressed on the record.

Mr. W. W. Doxsee, assistant seismologist, occupied this station from July 21 to September 7. The station was in operation at the time of the Japanese earthquake and good records were obtained from both No. 17 and No. 23.

After the instrument was partially dismounted for the return to Ottawa and after most of the camp equipment had been returned, it was found that conditions which had obtained while the seismograph was operating were such that the records may not have represented very accurately the ground movements. A fine spider thread, attached to the boom and from it directly to the pier about four inches below, was found to have interfered with any extended excursions of the boom. How long this thread was there could not be determined, although deflection tests had been made every time the instrument had a fresh paper sheet put on. However, as the operation of the instrument in its exposed position had not been satisfactory it was decided to return to Ottawa.

After the preliminary investigations had been carried out and arrangements made, piers built, etc., No. 23 was moved to a basement room of the dormitory of the Kemptville Agricultural School, about 35 miles approximately south of the home station. The principal, Mr. W. J. Bell, was most helpful in putting suitable quarters at our disposal. Again it was mounted with standard constants and exactly parallel with No. 17 at Ottawa, *i.e.* with the pillar at the south end of the pier. The instrument began to record on October 21 and continued to register till November 27. During this time some twenty earthquakes were recorded and also the great microseism storm of November 19-20. Mr. Doxsee was again in charge. Special precautions were taken to get time corrections by wireless.

So far as the work of examining the sheets has gone, there seems to be no possibility of correlating the microseisms, but the earthquake records show phases of similar nature for which the times can be rigorously compared.

THE GREAT EARTHQUAKES OF 1923

To the general public the Japanese catastrophe of September 1 looms up as the greatest earthquake of this or of many years past. But on February 3, last, an earthquake (No. 1387) was registered, which is the greatest record ever made at Ottawa. This seems to have occurred in the north Pacific. The exact location has not yet been fixed. The preliminary location from the records of Ottawa, Honolulu and Georgetown place it at a point $\varphi = 51°N.$, $\lambda = 170°E.$ This point is approximately 3,000 miles from Hawaii. In seven hours the tidal wave, travelling over 400 miles an hour, reached the shores of that island and, washing high up the bank, destroyed much of the shipping and caused quite extended damage to property along the shore as well as some loss of life.

The Japanese earthquake was well recorded at Ottawa on five instruments and at Shirley bay on Milne-Shaw No. 23.

EXHIBITS PREPARED

The Seismologic division prepared exhibits for the Canadian exhibition train to France and for the Canadian section at the British Empire exhibition. These consisted of transparencies from photographs of the seismographs and of the records registered at the Dominion Observatory.

THE NEW SEISMOGRAPH MOUNTING

A special mounting was devised for the Milne-Shaw seismograph No. 23, to enable the instrument to be readily turned into any azimuth from N-S component to E-W component registration, *i.e.* through 90°. The fact that the essential parts of the instrument can be supported on a disc of cast iron 3 inches thick and 2 feet in diameter, floating on the surface of mercury, made this possible. The recording apparatus can be moved over and adjusted rapidly by gauge. The mounting was designed by the seismologist and made at the Observatory machine shop by Mr. L. Christensen.

THE GENERAL OFFICE SYSTEM

Considerable time has been devoted to devising a system of office management which would define the routine work to be attempted, enable it to be done without needless repetition or copying of records and render the data readily accessible.

The new system was put into effect on December 1, 1923. It will be described in the monograph mentioned in the introduction to this present volume (page 2). It depended for its possibility of existence on a comparatively simple reproducing outfit for making *accurate* forms cheaply. On November 20, 1923, a new Edison-Dick Mimeograph, No. 78, was obtained, complete with full electrical equipment, arranged for hand or machine feed, together with a Mimeoscope, No. 1, completely equipped with tools. With this outfit, forms devised for the particular needs of this division were made out and reproduced. This equipment is also used in making bulletins sent out each month, and is invaluable for the work of the division. This system has now been in operation for some months. Notes are being kept of suggestions for improvement and simplification. Those which seem worth while will be incorporated in the forms for next year, 1925, as changes in the system will be made only at the ends of years.

DOMINION OBSERVATORY, OTTAWA,
FEBRUARY, 1924

APPENDIX A

SEISMOLOGIC PUBLICATIONS OF DR. OTTO KLOTZ

Not appearing in the series, *Publications of the Dominion Observatory*

1. Report of the Chief Astronomer, 1906.—Appendix I.
2. EARTHQUAKES.
   Trans. of the the Ottawa Lit. and Scien. Soc., 1906-07.
3. THE SURVEYOR AND EARTHQUAKES.
   Association of Ontario Land Surveyors, 1907.
4. Report of the Chief Astronomer, 1907.—Appendix II.
5. EARTHQUAKES AND THE INTERIOR OF THE EARTH.
   Jour., R.A.S.C., Vol. II, No. 2, 1908.
6. MICROSEISMS.
   Jour., R.A.S.C., Vol. II, No. 4, 1908.
7. Report of the Chief Astronomer, 1908.—Appendix I.
8. THE PERSIAN EARTHQUAKE OF JANUARY 23, 1909.
   Jour., R.A.S.C., Vol. III, No. 2, 1909.
9. Report of the Chief Astronomer, 1909.—Appendix I.
10. MICROSEISMS.
    Trans. Roy. Soc. of Can., Third Series, Vol. III, 1909.
11. SOME SCIENTIFIC CRUMBS FROM EUROPE.
    Jour., R.A.S.C., Vol. IV., No. 1, 1910.
12. THE SEISMOGRAPH.
    Jour., R.A.S.C., Vol. IV. No. 2, 1910.
13. EARTHQUAKE EPICENTRES.
    Jour., R.A.S.C., Vol. IV. No. 3, 1910.
14. Report of the Chief Astronomer, 1910.—Appendix I.
15. STEREOGRAPHIC PROJECTION TABLES.
    Jour., R.A.S.C., Vol. V. No. 3, 1911.
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APPENDIX B
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APPENDIX D

SYMBOLS USED

O = Time of shock at the epicentre or origin.
P = Preliminary, longitudinal waves, and time of arrival.
PR_1 = P waves, once reflected, and time of arrival.
PR_2 = P waves, twice reflected, and time of arrival.
etc.
S = Secondary, transverse waves, and time of arrival.
SR_1 = S waves, once reflected, and time of arrival.
SR_2 = S waves, twice reflected, and time of arrival.
etc.
e = Emersio, emergence of a phase not sharply defined and time of arrival, or may be used to qualify the nature of other phases.
i = Impetus, a sharply defined phase and time of arrival, or may be used to qualify the nature of other phases.
L = Long or surface waves, and time of arrival.
LR_1 = L waves reaching the station through the antipodes of that station, *i.e.* by a path 40,000 km. $- \Delta$
LR_2 = L waves reaching the station by a path 40,000 km. $+ \Delta$
Δ = The distance, measured about the surface of the earth from the epicentre to the station.
M = Maximum of L waves and time of arrival.
M_1, M_2, *etc.* = Successive maxima where these occur.
N-S Component = that seismograph which *registers* the earth movement in a north-south line. Similarly the E-W Component and the Vert. Component.
M-S = Refers to the Milne-Shaw seismographs.

A_E, A_N, A_Z = True earth movement (half amplitude), measured in microns. (Subscripts indicate the components east-west, north-south or vertical)

φ = Latitude.
λ = Longitude.
μ = Micron = ·001 mm.
h = Height above sea-level.
ca. = approximately.
T_o = Oscillation time (complete), of undamped seismograph.
h.m.s. = Hours, minutes, and seconds, in Greenwich Mean Time, midnight to midnight.
I = Bosch, photographic seismograph, N-S Component.
II = Bosch, photographic seismograph, E-W Component.
17 = Milne-Shaw seismograph, at present an E-W Component.
23 = Milne-Shaw seismograph, used experimentally in 1923.
D_1 = E-W Component of Deformation Instrument.
D_2 = N-S Component of Deformation Instrument.
W = Wiechert, vertical seismograph.
ϵ = Damping ratio.
V = Magnification.
V_L = Velocity of L waves.
g = grammes.
lb. = pounds avoirdupois.
Kgm. = kilogrammes.
mm. = millimeters.
m. = meters.

Where the interpretation of a phase is doubtful, though the time may be accurately known, a question mark follows the symbol for the phase, as P?.

Where the exact time is not known, though confidence in the interpretation of the phase exists, brackets surround the figures. Similar brackets indicate the doubtful figures in other parts of the report.

Subscripted letters after the symbol for phase indicate the component or the instrument from which the phase was read, as P_E, L_{17}, *etc.*

"Small" in the amplitude column, indicates a true earth amplitude, smaller than 1 micron.

"HALIFAX RECORD" and "SASKATOON RECORD" indicate the Ottawa readings from the Mainka seismographs at Dalhousie University and at the University of Saskatchewan, respectively.

DEPARTMENT OF THE INTERIOR
CANADA

HON. CHARLES STEWART, *Minister* W. W. CORY, C.M.G., *Deputy Minister*

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

R. MELDRUM STEWART, M.A., *Director*

Vol. VII

SEISMOLOGY

No. 2

The Location of Epicentres, 1921

BY

W. W. DOXSEE, M.A.

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1925

LOCATION OF EPICENTRES, 1921

The determination of seismic epicentres is confined to those earthquakes of which at least a trace was registered at Ottawa. During the year 1921 one hundred and seven records, serially numbered from 1144 to 1250, were registered by the seismographs at the Dominion Observatory. Fifteen of these were sufficiently well marked in phase to yield accurate values for O, the Greenwich Mean Time of the disturbance at its origin, and Δ, the distance in kilometres from Ottawa to the epicentre. Nine other seismograms were read for time and distance, but the results obtained were regarded as doubtful. Using all the data available from other stations in conjunction with that from our own, it was possible to locate thirty-seven epicentres accurately and fifteen others approximately, while five were assigned doubtful locations. Of the fifty-four other earthquakes, designated in the tables as "No Locations" because of the impossibility of determining an epicentre, due to insufficient or discordant data, seven were located either accurately or approximately through press despatches or reports from other stations. These latter, however, are listed in the column " Other Locations," as column five contains the geographical coördinates of only those epicentres which were obtained by means of the stereographic projection method. The apparent discrepancy in the total number of quakes is accounted for by the fact that four records, viz. 1162 of Feb. 27th, 1179 of Mar. 30th, 1208 of June 28th, and 1240 of Oct. 15th, are dual, and two sets of geographical coördinates were given for each of these earthquakes.

It is to be noted that the values for O and Δ given in columns three and four, opposite their respective stations, are not always in agreement with those supplied by the station furnishing the data, as in all cases the readings given for P and S are accepted as correct and the quantities O and Δ are computed on the basis of the Klotz Seismological Tables. By this practice uniformity is obtained in the location work. In some instances it is possible to interpret *e* or *i* phases in terms of P or S, thereby gaining further evidence in support of the listed values of λ, φ, and O. All Δ values which vary greatly from the measured distance from the station to the epicentre are tabulated in the last column.

DOMINION OBSERVATORY,
OTTAWA, CANADA, March, 1924.

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1144	Strasbourg......	7-05-24	9300	φ = 35° N		Victoria (5200)
Jan. 2	Algiers........	7-06-19	10640	λ = 134° E		Cartuja 2780
	Wien..........	7-06-28	9000	O = 7-06-34		La Paz (11930)
	Hamburg.......	(7-05-58)	(9300)			
	Tokio..........	7-07-56	545			
	Manila.........	7-06-46	2580			
	Uccle..........	7-06-53	8640			
	Naples.........	7-06-45	9400			
	Paris..........	7-06-41	9160			
1145	No Location				Sydney gives	La Paz (10320)
Jan. 7					φ = 13° S	Cartuja 11400
					λ = 151° E	Perth 2440
						Wellington 3070
						Sydney 2260
1146	Ottawa.........	6-35-23	3910	φ = 14°·5 N		Georgetown 4200
Jan. 8	Ithaca.........	(6-36-00)	(3470)	λ = 93° W		
	Chicago	6-35-41	2980	O = 6-35-40		
	La Paz	6-35-38	4410			
1147	Ottawa.........	12-55-03	6480	φ = 13° S		Coimbra 10140
Jan. 9	Georgetown	12-54-59	5780	λ = 73°·5 W.		Uccle 9450
	Chicago........	12-54-56	6220	O = 12-55-02		
	Balboa	12-54-57	2540			
	Cartuja	12-55-06	9280			
	La Paz.........	12-55-13	680			
1148	No Location					Chicago (6350)
Jan. 9						La Paz (8600)
						Sydney 3550
						Batavia 8540
1149	No Location					Sydney (6080)
Jan. 19						
1150	Washington.....	21-01-33	3450	φ = 12° N		Ottawa (2600)
Jan. 20	Balboa.........	21-02-44	435	λ = 83°·5 W		Toronto 5100
	La Paz.........	21-02-24	3130	O = 21-02-14		Chicago 5200

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1151	Ottawa..........	8-22-37	3420	φ = 16° N	Victoria gives	Denver	545
Feb. 4	Halifax..........	(8-22-36)	(4340)	λ = 91°·5 W	near Guatemala.	Chicago	5860
	Ithaca..........	8-21-56	3680	O = 8-22- 41		Belgrade	8680
	Wien..........	8-22-08	10600		Toronto and	Naples	9080
	Strasbourg......	8-22-52	9100		Harvard give		
	Victoria..........	8-23-12	3950		Tehauntepec,		
	Toronto..........	8-22-36	3600		Mexico.		
	Vieques......,..	8-23-07	2560				
	Cheltenham.....	8-21-43	3360				
	Paris..........	8-23-00	8750				
	Tucson..........	8-22-27	2580				
	Cartuja..........	8-22-39	8700				
	La Paz..........	8-22-40	4300				
	Besançon.......	8-23-19	8600				
	Georgetown.....	8-21-41	3500				
	Washington.....	8-20-44	3440				
	St. Louis........	8-22-41	2440				
	Fordham.......	8-23-19	2960				
	Balboa..........	8-22-14	1620				
	Northfield......	8-22-36	3440				
	Stonyhurst......	8-23·2	8320				
	Athens..........	8-22-37	10200				
	Algiers..........	8-23-02	9020				
	Hamburg........	8-22-58	9090				
	Harvard..........	8-22-26	3420				
	Coimbra........	8-21-53	8220				
	Lemberg........	8-23·5	9280				
	Firenze..........	(8-22-58)	(8800)				
	Dyce..........	8-22-06	8800				
	Uccle..........	8-22-45	8980				
	Lick..........	8-23-23	3150				
	Königsberg......	8-23-12	9220				
	Berkeley........	8-24-23	3230				
1152	No Location					Wien	(9600)
Feb. 6						Chicago	(6640)
						Harvard	(5325)
						Uccle	8450
1153	No Location					Sydney	4300
Feb. 10							
1154	No Location					Victoria	4120
Feb. 11						Ottawa	(7500)
						La Paz	16850
						Stonyhurst	5320
						Harvard	(8500)
						Sydney	5750
1155	No Location					La Paz	(3550)
Feb. 11						Balboa	(460)
						Harvard	(4945)

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1156	Manila.........	0-59-17	2150	$\varphi = 1°\cdot5$ S	Batavia and	La Paz (9000)
Feb. 14	Sydney.........	1-00-46	4780	$\lambda = 125°$ E	Manila give	
	Batavia.........	1-00-43	2400	O = 1-00-15	Mindanao.	
				Location		
				approximate only		
1157	Sydney.........	14-33-46	4060	$\varphi = 10°$ N		Victoria 6600
Feb. 19	Batavia.........	14-33-37	3020	$\lambda = 129°$ E		Chicago (8800)
	La Paz	14-33-55	16670	O = 14-33-46		Uccle (8800)
				Location		
				approximate only		
1158	Victoria.........	18-29-23	5740	$\varphi = 44°$ N		Strasbourg 6700
Feb. 19	Chicago.........	18-24-14	7900	$\lambda = 161°$ E		La Paz 15600
	Stonyhurst......	18-23·1	9020	O = 18-23 ca.		Tokio 100
	Wien............	(18-20-58)	(9310)	Location		Wellington 5000
	Coimbra.........	(18-22-31)	(12020)	doubtful.		Sydney 3590
	Lemberg.........	18-20·4	8800			
	Uccle............	18-22-53	8600			
	Budapest........	18-20-37	10340			
1159 Feb. 21	No Location					Victoria 650
1160	No Location					Strasbourg (10320)
Feb. 21						Victoria 1510
						Berkeley (1540)
1161 Feb. 21	No Location					No data.
1162	Ottawa..........	18-29-56	8780	$\varphi = 47°\cdot5$ N		Denver (4220)
Feb. 27	Ithaca..........	18-30-27	8280	$\lambda = 167°$ E		Firenze 2340
	Strasbourg......	(18-30-29)	9780	O = 18-30-20		Budapest 7650
	Cartuja..........	18-29-13	11760	Location		
	Georgetown......	18-30-39	7080	doubtful.		
	Algiers.........	18-31-01	9230			
	Athens..........	(18-29-07)	(10940)			
	Wien............	(18-30-25)	(9860)			
	Harvard.........	18-30-55	8420			
	Coimbra.........	18-30-17	9600			
	Uccle............	18-31-08	8920			
	Besançon........	(18-30-25)	(10000)			
	Tucson..........	18-23-39	8680	$\varphi = 19°\cdot5$ S	Tokio gives	Victoria 6820
	Perth...........	18-22-26	7750	$\lambda = 172°$ W	near Samoa Is.	La Paz 9520
	Manila..........	18-23-31	8220	O = 18-23-28		Washington 9950
	Tokio...........	18-23-33	7950			Chicago 9500
	Wellington......	18-23·6	2600			Honolulu 4120
	Sydney..........	18-23-37	3680			Naples 9300
	Batavia.........	18-23-47	8650			Paris 13000
	Lick............	18-23-38	8260			

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1163 Mar. 3	Strasbourg ..... Tokio .... Besançon....... Uccle.......... Naples......... Paris.......... Königsberg.....	3–02–27 3–02–28 (3–02–43) 3–02–28 3–02–58 3–02–14 (3–01–15)	9280 194 (9250) 9200 8800 9740 (9660)	φ = 37° N λ = 137° E O = 3–02–21	Tokio reports quake felt at north part of Iwaki.	Cartuja La Paz Algiers Sydney Chicago Batavia	10100 15750 9250 7270 (6920) 8520
1164 Mar. 3	Perth.......... Sydney......... Melbourne......	8–20–22 8–20–32 8–20·8	3110 5560 5100	φ = 6° S λ = 105°·5 E O = 8–20–30 Location approximate.		La Paz Harvard	16150 (11420)
1165 Mar. 5	La Paz......... Manila......... Zi-ka-wei.......	(6–25–06) 6–23–37 6–24–17	(16100) 3480 3670	φ = 15° N λ = 152° E O = 6–24·3 Location doubtful.			
1166 Mar. 6	Ottawa......... Toronto........ Harvard........ Washington..... Chicago........ St. Louis........ Fordham....... Georgetown..... Uccle.......... Berkeley........ La Paz.........	7–24–52 7–25–26 7–24–50 7–24–28 7–24–58 7–23–46 7–24–50 (7–25–09) 7–24–38 7–25–09	3740 3150 4000 3350 2720 2500 3200 3420 (9350) 1950 6650	φ = 24° N λ = 119° W O = 7–24–49		Victoria	2170
1167 Mar. 10	Perth.......... Sydney.........	(20–04–46) 20–05–14	(3520) 2690	φ = 11°·5 S λ = 125° E O = 20–05 Location approximate.			
1168 Mar. 12	Ottawa......... La Paz......... Chicago........ Balboa.........	(10–29–08) 10–30–24 10–30–44	(4830) 3020 3550 (555)	φ = 7° N λ = 85°·5 W O = 10–30·2 Location approximate.			
1169 Mar. 16	No Location					Sydney	2560

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1170 Mar. 21	La Paz........ Ithaca.......... Balboa......... Uccle...........	4-06-20 4-06-33 4-06-49	2680 4220 450 9160	$\varphi = 4°\cdot 5$ N $\lambda = 79° 33'$ W O = 4-06-34		 Chicago	 3170
1171 Mar. 21	No Location					La Paz	2690
1172 Mar. 24	No Location					La Paz Sydney Melbourne	12300 3240 3250
1173 Mar. 24	No Location					No data.	
1174 Mar. 24	Ottawa......... Algiers......... Ithaca.......... Coimbra........ Washington..... St. Louis........ De Bilt .... Georgetown..... Zi-ka-wei........ Uccle............ Sydney......... Barcelona....... Naples......... Paris...........	14-41-58 14-41-50 (14-41-44) 14-41-27 14-40-52 (14-42-11) 14-41-38 14-41-54 14-41-54 14-41-54 14-41-23 (14-42-33) 14-41-58 (14-40-51)	8040 9600 (8360) 9900 8700 (7850) 8440 8650 3520 8400 9600 9050 8800 (9950)	$\varphi = 51°$ N $\lambda = 156°\cdot 5$ E O =14-41-43		La Paz Strasbourg Chicago Tokio Belgrade Melbourne Budapest Besançon	15730 3700 6820 (1190) 4150 9020 11680 (3180)
1175 Mar. 25	No Location					Victoria Harvard Coimbra	1100 (7590) (4210)
1176 Mar. 25	No Location					No data.	

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1177	Ottawa.........	7-49-17	3600	φ = 13° N	Victoria gives	Athens	8880
Mar. 28	Saskatoon.......	7-49-42	4650	λ = 86°·5W	Nicaragua.	Naples	8800
	Cartuja.........	7-49-36	8500	O = 7-49-18		Firenze	10480
	La Paz.........	7-49-12	3730			Wellington	9280
	Georgetown.....	7-49-12	3020			Melbourne	(11920)
	Stonyhurst......	7-49·5	8320				
	Strasbourg......	7-49-34	9060				
	Ithaca..........	7-48-58	3360				
	Algiers.........	7-49-31	9020				
	Paris...........	7-49-29	8780				
	Victoria........	7-48-59	5300				
	Toronto.........	7-48-38	3810				
	Hamburg.......	7-49-35	9000				
	Wien...........	7-49-31	9440				
	Honolulu.......	7-49-26	7500				
	Porto Rico......	7-49-12	2460				
	Besançon.......	7-49-30	9050				
	Cheltenham.....	7-48-28	3250				
	Tucson.........	7-49-38	2930				
	Harvard........	7-49-16	3480				
	Barcelona......	7-49-24	8920				
	Coimbra........	7-49-30	8060				
	Washington.....	(7-48-10)	(3040)				
	Chicago........	7-48-00	4000				
	Lick...........	7-49-25	4180				
	St. Louis.......	7-49-21	2780				
	Berkeley........	7-49-22	4260				
	Fordham.......	7-49-09	3330				
	Northfield......	7-50-10	3450				
	Balboa.........	7-49-32	920				
	De Bilt.........	7-49-34	8850				
	Uccle..........	7-49-30	8850				
	Belgrade........	7-48-49	10140				
	Apia...........	7-49-35	9500				
	Lemberg........	7-49-31	9700				
1178	Osaka..........	2-11-35	2035	φ = 48° N		Wien	(12260)
Mar. 29	Zi-ka-wei.......	2-11-59	2820	λ = 148°·5 E		Sydney	(11460)
	Uccle...........	(2-11-51)	(8800)	O = 2-11-48 Location approximate.			

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1179	Osaka	15-02-19	4380	φ = 3° S		Ottawa	13000+
Mar. 30	Honolulu	15-02-19	8360	λ = 125°·5 E		La Paz	16200
	Manila	15-03-12	1860	O = 15-02-23		Chicago	5150
	Tokio	15-01-45	4750	Location		Georgetown	(2170)
	Zi-ka-wei	15-02-46	3550	approximate.		Sydney	3360
	Melbourne	15-02·2	3520				
	Batavia	15-02-07	2230				
	Strasbourg	15-05-29	1530	φ = 38° N			
	Algiers	15-05-54	1660	λ = 21°·5 E			
	Wien	15-05-22	1130	O = 15-05-36			
	Coimbra	15-05-56	2480				
	Belgrade	15-05-57	430				
	Naples	15-06-17	440				
	Firenze	15-05-14	1270				
	Athens	15-06-04	500				
	Paris	15-05-10	2120				
	Besançon	(15-04-38)	(2000)				
1180	Strasbourg	(4-06-35)	(9780)	φ = 2°·5 N	Batavia reports	La Paz	15850
April 1	Wien	4-06-41	9250	λ = 98° E	destructive quake	Osaka	8200
	Algiers	4-06-57	9680	O = 4-06-58	at Tapanuli,	Tokio	11120
	Hamburg	4-07-42	9020		Sumatra.	Chicago	(9560)
	De Bilt	(4-07·3)	(9400)			Zi-ka-wei	2690
	Uccle	4-06-55	9850			Melbourne	4340
	Batavia	4-06-29	1390			Athens	9780
	Manila	4-06-34	2820			Ebro	9440
	Naples	4-07-14	8800				
	Budapest	4-07-02	9230				
	Paris	4-07-14	9560				
1181	Osaka	12-00-41	5920	φ = 12°·5 S		La Paz	11800
April 1	Melbourne	(12-00·3)	3420	λ = 162°·5 E		Tokio	3800
	Sydney	12-00-56	2590	O = 12-00-24		Chicago	(8440)
	Apia	(11-59-40)	(3100)			Uccle	9210
						Ebro	(8440)
1182	Strasbourg	9-36-51	9800	φ = 25° N	Tokio gives	La Paz	15900
April 2	Osaka	9-35-42	2410	λ = 125° E	Ishigaki I.	Coimbra	8800
	Wien	9-37-02	9120	O = 9-37-03		Chicago	(4040)
	Marseilles	(9-37-47)	(9200)			Belgrade	3230
	Algiers	9-36-53	10140			Melbourne	6220
	Hamburg	9-36-53	9370			Naples	8480
	Tokio	9-37-59	1390			Ebro	(9660)
	De Bilt	9-37-40	9060			Barcelona	(7300)
	Zi-ka-wei	9-36-31	1080				
	Uccle	9-37-11	9420				
	Lemberg	9-36·8	8800				
	Sydney	9-36-45	7040				
	Batavia	9-36-50	3620				
	Manila	9-36-32	1150				
	Budapest	9-37-09	9280				
	Paris	9-37-27	9380				
	Besançon	(9-37-54)	(9350)				

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1183 April 5	No Location					No data.	
1184 April 10	Ottawa......... Strasbourg...... Algiers......... Georgetown..... De Bilt........ Chicago........ Uccle........... La Paz......... Ebro........... Paris..........	13–40–05 13–40–02 13–40–26 (13–38–39) 13–40–08 13–39–08 13–40–10 13–40–38 13–40–15 13–40–08	4100 8400 9230 (5040) 7900 4400 7960 9680 8780 8150	φ = 50°·5 N λ = 131°·5 W O = 13–40–00	La Paz gives φ = 49°·5 N λ = 130° W Victoria reports quake felt at northern part of Queen Charlotte islands.	St. Louis	(830)
1185 April 10	No Location					No data.	
1186 April 12	De Bilt........ Paris..........	(7–29–24) 7–29–25	(7650) 7950	φ = 52° N λ = 133°·5 W O = 7–29–25 Location approximate only	Victoria reports quake near Queen Charlotte islands.	St. Louis	710
1187 April 20	No Location					Uccle La Paz	4650 5750
1188 April 22	No Location					La Paz Melbourne Sydney Ebro Paris	9380 4560 2920 (8800) 15000+
1189 April 25	No Location					Strasbourg Belgrade Melbourne Perth Sydney	7380 890 2300 4450 2820
1190 April 27	No Location					No data.	

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1191 May 1	Ottawa.........	5-38-43	3980	φ = 20° N	La Paz gives		
	Saskatoon.......	(5-38-40)	3740	λ = 102° W	φ = 20°·5 N		
	Halifax.........	(5-38-43)	4750	O = 5-39-10	λ = 102° W		
	Chicago.........	5-38-37	3140				
	La Paz.........	5-38-54	5650				
	St. Louis.......	5-38-55	2620				
	Strasbourg......	(5-39-40)	(9230)				
	Hamburg......	(5-39-21)	(9480)				
	Tucson.........	5-39-10	1620				
	Wien..........	5-39-46	9600				
	Coimbra........	5-38-54	9480				
	Algiers.........	5-39-36	9500				
	De Bilt	(5-39-23)	(9420)				
	Georgetown.....	5-40-38	2820				
	Ithaca..........	5-40-39	2780				
	Washington.....	5-39-51	3070				
	Uccle..........	5-39-12	9510				
	Stonyhurst......	5-38·6	9900				
	Ebro...........	5-39-26	9400				
	Barcelona.......	5-39-22	9480				
	Paris...........	5-39-23	9320				
1192 May 12	Honolulu.......	3-40-17	5950	φ = 7°·5 S		Victoria	4660
	Perth..........	3-40-09	4880	λ = 155° E			
	Sydney.........	3-40-15	2960	O = 3-40-17			
	Wellington......	3-40-26	4220				
1193 May 14	Perth..........	11-25-16	1950	φ = 24°·5 S		La Paz	(9520)
	Sydney.........	11-17-29	5250	λ = 97°·5 E		Paris	11000
	Batavia.........	11-15-53	2260	O = 11-17 ca. Location and O doubtful.			
1194 May 14	Honolulu.......	20-17-42	6110	φ = 7°·5 S		Algiers	(10020)
	Sydney.........	20-18-20	2960	λ =154° E		Perth	6710
				O = 20-18·0		La Paz	12350
				Location doubtful.		Paris	13500
1195 May 14	No Location					No data.	
1196 May 14	Cheltenham.....	22-10-28	3100	φ = 20°·5 N			
	Chicago........	22-09-32	2800	λ = 101°·5 W			
	La Paz.........	22-09-34	5530	O =22-09-50			
1197 May 16	No Location					La Paz	580
						Sydney	2850

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1198	Strasbourg	0-43-15	4830	$\varphi = 37^\circ$ N	De Bilt gives	Chicago	9000
May 20	Coimbra	0-43-19	6370	$\lambda = 66^\circ\cdot 5$ E	$\varphi = 37^\circ\cdot 9$ N	Wien	(950)
	Algiers	0-43-14	5560	O = 0-43-12	$\lambda = 67^\circ\cdot 4$ E	Stonhyurst	3250
	Dyce	0-43-12	5380		Uccle gives	La Paz	(12300)
	De Bilt	0-43-14	4980		$\varphi = 37^\circ\cdot 5$ N	Batavia	(5100)
	Uccle	0-43-12	5070		$\lambda = 67^\circ\cdot 3$ E		
	Athens	0-43-18	3720		Naples gives		
	Ebro	0-43-16	5600		South Turkestan		
	Naples	0-43-17	4400				
	Budapest	0-42-40	3960				
	Barcelona	0-43-18	5440				
	Paris	0-43-13	5240				
	Besançon	(0-43-03)	(5150)				
1199	Strasbourg	8-43-12	9450	$\varphi = 14^\circ\cdot 5$ N	Tokio and De Bilt	Coimbra	10680
May 21	Osaka	8-42-13	2520	$\lambda = 121^\circ\cdot 5$ E	give off east	Chicago	8420
	Hamburg	8-42-54	9500	O = 8-42-29 ca.	coast of Manira I.	Uccle	(5850)
	Honolulu	8-42-25	8100	Location		Naples	2270
	Tokio	8-41-16	3550	approximate.	Manila reports		
	Zi-ka-wei	8-42-16	2010		quake northeast		
	Wien	8-43-16	8940		of Samar I.		
	Lemberg	8-42·6	9280				
	La Paz		18000				
	De Bilt	8-43·4	9380				
	Melbourne	8-41·8	6220				
	Sydney	8-41-44	6050				
	Budapest	8-42-46	9250				
1200	No Location					Uccle	2680
May 21						Paris	(2180)
1201	Strasbourg	(22-26-04)	(8640)	$\varphi = 47^\circ\cdot 5$ N	Tokio and De Bilt	Victoria	(4660)
May 21	Osaka	22-25-35	2440	$\lambda = 155^\circ\cdot 5$ E	report quake in	Honolulu	2150
	Hamburg	22-25-51	8360	O =22-25-51	Kurile Is.	Coimbra	12400
	Tokio	22-25-54	1950			Belgrade	(7650)
	Zi-ka-wei	22-26-02	3200				
	Chicago	22-25-46	8250				
	Lemberg	22-25·7	8320				
	Wien	22-25-47	8800				
	Uccle	22-25-53	8720				
	De Bilt	22-25-53	8580				
	Batavia	22-25-57	7820				
	Budapest	22-25-21	9080				
	Paris	22-25-59	8880				
	Ebro	22-26-06	9440				
1202	St. Louis	20-53-43	3150	$\varphi = 51^\circ$ N	Victoria reports		
May 28	Victoria	.	300	$\lambda = 126^\circ$ W	quake felt at		
	Chicago	20-54-14	2920	O =20-53-58	Estevan, Nootka		
					and Quatsino.		

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1203	No Location					No data.	
June 4							
1204	No Location					No data.	
June 15							
1205	No Location					Tucson	360
June 17							
1206	No Location					No data.	
June 17							
1207	No Location					Chicago	3580
June 25						Honolulu	2160
						Victoria	840
1208	Victoria..........	14-06-13	6860	φ = 46° N		Ebro	(10700)
June 28	Chicago.........	14-06-39	8740	λ = 141°·5 E		Naples	4220
	Algiers.........	(14-07-07)	(8480)	O = 14-06-50			
	Coimbra.........	14-07-30	9900	Location and			
				O approximate.			
	Perth...........	13-59-06	5100	φ = 40° S	Sydney reports	Melbourne	(3070)
	Sydney..........	13-58-39	2340	λ = 176° E	quake felt in	La Paz	9340
	Batavia.........	13-58-53	7650	O = 13-58-52	New Zealand at	Manila	3810
					Hawkes Bay.		
					φ = 39°·8 S		
					λ = 177°·4 E		
1209	Ottawa..........	2-10-08	3190	φ = 57° N	De Bilt reports	Wien	(2620)
June 30	Strasbourg......	(2-09-58)	(2970)	λ = 35° W	quake in north		
	Toronto.........	2-09-51	3070	O = 2-10-08	Atlantic.		
	Chicago.........	(2-10-22)	(4020)				
	Uccle...........	2-10-01	2580				
	De Bilt.........	2-10-09	2540				
	Coimbra.........	2-10-10	2660				
	Paris...........	2-10-01	2640				
	Besançon........	2-10-21	2800				
	Ebro............	2-10-15	2960				
1210	Strasbourg......	(14-19-11)	(9050)	φ = 30° N	De Bilt gives	Chicago	5780
July 4	Wien............	14-19-42	8550	λ = 127° E	Pacific ocean	Belgrade	1420
	Sydney..........	14-18-06	6460	O = 14-18-30	near Japan.	Coimbra	12580
	Zi-ka-wei.......	14-18-14	1940	Location and	Tokio reports		
	De Bilt.........	(14-18-18)	(9510)	O approximate	quake near		
	Tokio...........	14-18-16	1030	only.	Vladivostock and		
	Manila..........	14-19-08	1780		felt at Hakodate,		
	Batavia.........	14-17-48	4740		Fukusima and		
	Budapest........	14-18-00	9350		Mito.		
					Manila reports		
					quake felt at		
					West Luzon.		

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1211 July 7	No Location					Honolulu 1320 La Paz 3500 Melbourne 3420 Uccle (8800) Sydney 2750 Paris 11650
1212 July 8	No Location					Chicago (2560) La Paz (7400)
1213 July 9	No Location					No data.
1214 July 10	No Location					No data.
1215 July 12	No Location					No data.
1216 July 13	Uccle......... Coimbra........ La Paz.........	10-16·0 10-18-53 (10-18-11)	9900 9150 (4580)	φ = 11°·5 N λ = 99° W O =(10-18-30)		Chicago (3880)
1217 July 24	No Location				Manila reports quake felt at SE. Luzon and NE. Samar.	Ottawa (3700) Zi-ka-wei 2035
1218 July 25	No Location					Manila 1550 Zi-ka-wei 810
1219 July 25	No Location					No data.
1220 July 31	No Location					Victoria 4660 Honolulu 2590 Sydney 2620
1221 Aug. 14	Rocca di Papa... Strasbourg...... Algiers......... Uccle........... Wien........... Hamburg........ De Bilt .... Coimbra........ Belgrade........ Paris........... Besançon....... La Paz.........	13-15-18 13-15-24 13-15-25 13-15-23 13-15-19 13-15-18 13-15-29 13-14-43 13-14-26 13-15-21 13-15-26 	3910 4620 4260 5000 4220 5000 4980 5480 3820 5050 4650 (12300)	φ = 15° N λ = 39° E O = 13-15-14	" Nature " of Aug. 25, 1921, and Strasbourg report quake in Eritrea, Abyssinia.	Stonyhurst 3520

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1222 Aug. 16	No Location					No data.	
1223 Aug. 17	No Location					La Paz	(3140)
1224 Aug. 19	No Location					Chicago	1190
1225 Aug. 21	No Location					Uccle	5400
1226 Aug. 23	Ottawa........	20–17–29	3910	$\varphi = 66°$ N	Uccle gives	Honolulu	6320
	Rocca di Papa...	20–18–09	2770	$\lambda = 22°$ W	$\varphi = 65°{\cdot}6$ N		
	Strasbourg.......	20–17–13	2620	O =20–17–23	$\lambda = 22°{\cdot}1$ W		
	Toronto	(20–17–30)	(3600)		De Bilt and		
	Algiers........	20–17–22	3520		Coimbra report		
	Marseilles.......	20–17–34	2920		quake at or near		
	Georgetown.....	(20–17–14)	(4800)		Iceland.		
	Washington.....	(20–17–09)	(4520)				
	Uccle........	20–17–21	2230				
	Chicago........	20–17–45	4370				
	Wien..........	20–17–17	2900				
	Hamburg.......	20–17–33	2090				
	De Bilt........	20–17–16	2200				
	Dyce..........	20–17–17	1430				
	Coimbra.......	20–16–45	3230				
	Belgrade........		3380				
	Paris..........	20–17–15	2390				
	Besançon.......	20–17–16	2690				
1227 Aug. 25	No Location					No data.	
1228 Aug. 25	No Location				Manila reports quake felt at SE. Luzon.	No data.	
1229 Aug. 27	No Location				Felt at Arnprior, Hawkesbury, Cornwall, Ontario; and at Montreal, Vaudreuil, Ste. Anne de Bellevue, Lachine, Joliette, Cartierville, Sorel, St. Jérôme, Ste. Thérèse, St. Faustin, St. Jovite, Labelle and Lac Superieur, Quebec province.	Ottawa	220

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1230 Aug. 29	No Location					Chicago 315
1231 Sept. 5	Strasbourg......	19–56–49	9120	$\varphi = 46°\cdot5$ N	De Bilt gives	Honolulu 9560
	Osaka..........	19–56–37	2140	$\lambda = 152°\cdot5$ E	Kurile Is.	Manila 2620
	Pola............	19–57–06	9020	O = 19–57–04		
	Uccle...........	19–57–14	8520			
	Wien...........	(19–57–48)	(7720)			
	Sydney.........	(19–57–53)	(8500)			
	Zi-ka-wei.......	19–56–50	3070			
	Washington.....	19–57–03	9230			
	Chicago........	19–56–07	9500			
	Hamburg.......	19–57–01	8320			
	De Bilt	19–57–05	8520			
	Belgrade........	19–56–57	8800			
	Batavia.........	19–56–52	7450			
	Budapest.......	(19–56–45)	(8680)			
	Barcelona......		(9720)			
	Coimbra........	19–57–46	9320			
	Paris...........	19–57–15	8780			
	La Paz.........		(14400)			
	Besançon.......	19–56–58	9150			
1232 Sept. 8	No Location					Victoria (650)
						Tucson 330
						Chicago 2690
1233 Sept. 11	Lemberg........	4–02·6	9520	$\varphi = 1°$ S	Sydney gives	Ottawa (12340)
	Honolulu.......	4–02–02	9980	$\lambda = 108°\cdot5$ E	$\varphi = 13°$ S	Fordham 2480
	Osaka..........	4–01–55	5380	O = 4–02–06	$\lambda = 111°$ E	Chicago 12460
	Pola...........	4–02–44	10050	Location	Batavia gives	St. Louis (3520)
	Wien...........	4–02–24	9980	Rough	$\varphi = 11°$ S	Victoria (4650)
	Sydney.........	4–01–28	4680	approximation	$\lambda = 111°$ E	Marseilles (9650)
	Zi-ka-wei.......	4–02–40	3780	only.	Felt all over	Strasbourg (10260)
	Batavia........	(4–01–36)	(750)		islands of Java,	Algiers 10140
	Coimbra........	4–01–32	13200		Madura, Bali and	Georgetown (10140)
					Lombok.	Dyce 4450
						Rio de Janeiro 6000
						Manila 3650
						Belgrade 2480
						Athens 11080
						Budapest 8080
						Barcelona 10140
						Paris (9550)
						Naples 2560
						La Paz 17500

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1234	Ottawa........	2-48-00	4370	φ = 54° N	Sydney gives	La Paz 5450
Sept. 13	Chicago........	2-47-58	4320	λ = 165° W	Aleutian Is.	Batavia (4150)
	Algiers........	2-37-47	9480	O = (2-45)		Athens (4980)
	Pola........	2-50-41	7850	Location and		Wien (11740)
	Sydney........	2-37-38	9250	O only rough		Rio de Janeiro3150
	Hamburg........	2-44-31	8500	approximation.		
	Belgrade........	2-44-28	7950			
	Coimbra........		(9500)			
1235	No Location				De Bilt gives a	No data.
Sept. 19					doubtful location	
					of N. Pacific ocean	
1236	Strasbourg......		14200	φ = 2° N	De Bilt gives	Victoria 6860
Sept. 19	Honolulu........	23-16-34	5050	λ = 159°·5 E	origin as S.	Toronto (8080)
	Sydney........	23-14-28	4060	O = (23-16·3)	Pacific ocean.	Wien (7340)
	La Paz........	23-17-53	14800	Location and		Chicago 7320
				O approximate		Belgrade 2010
				only.		Perth 6580
1237	No Location					Belgrade 910
Sept. 20						
1238	Strasbourg......	11-01-41	4420	φ = 15°·5 N	Hamburg reports	
Sept. 21	Algiers........	11-01-26	4300	λ = 39° E	quake felt in	
	Wien........	(11-01-05)	(4480)	O = 11-01-27	Eritrea,	
	Hamburg........	11-01-36	4860		Abyssinia.	
	Belgrade........		3170			
1239	No Location				De Bilt gives	La Paz 2930
Oct. 1					Central America (?)	
1240	Osaka........	4-58-17	6300	φ = 12° S	Sydney gives	Ottawa (11000)
Oct. 15	Sydney........	4-57-42	2920	λ = 167°·5 E	φ = 11° S	
	Zi-ka-wei........	4-58-17	6820	O = 4-57-55	λ = 165° E	
	Batavia........	4-57-22	7520		Near Solomon Is.	
	Wien........	5-05-16	9060	φ = 51° N		Toronto 7250
	Victoria........	5-05-04	2760	λ = 160°·5 W		Georgetown (6450)
	Algiers........	5-05-00	9940	O = 5-05-17		Honolulu 2610
	Coimbra........	5-05-49	9350			Chicago 8200
						La Paz 10050

LOCATION OF EPICENTRES, 1921.

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1241	Ottawa.........	(6-03-15)	(7140)	φ = 19° S	La Paz and De Bilt	Chicago	(6280)
Oct. 20	Algiers.........	6-03-35	9230	λ = 70°·5 W	report quake at	Strasbourg	9250
	Georgetown.....	6-03-13	6400	O = 6-03-27	Iquique, Chile.	Victoria	2035
	Tucson.........	6-03-44	6700			Pola	9650
	Porto Rico......	6-03-41	3720			Wien	5220
	Cheltenham.....	6-03-32	6240			Sydney	8320
	Washington	6-03-11	6450			Firenze	8700
	Balboa.........	6-02-59	3240			Stonyhurst	2220
	Barcelona.......	6-03-56	9060			Hamburg	(9320)
	Coimbra........	6-03-13	8950			Belgrade	6950
	La Paz.........	6-03-33	315			Budapest	4740
						Paris	8620
						Naples	6640
						Besançon	(8700)
1242	Chicago........	3-37-31	3110	φ = 15° N			
Nov. 2	Tucson.........	3-37-58	2160	λ = 115° W			
	La Paz.........	3-37-20	5580	O = 3-37-36			
1243	No Location				La Paz reports	La Paz	1000
Nov. 2					quake felt at	Chicago	5420
					Lima, Peru.		
1244	No Location					No data.	
Nov. 6							
1245	Honolulu.......	16-00-20	7820	φ = 7° N	Manila gives	Victoria	6320
Nov. 7	Zi-ka-wei.......	15-59-59	2590	λ = 128°·5 E	SE. of Mindanao.	Strasbourg	(12820)
	Batavia........	15-59-40	2640	O =15-59-45		Pola	(10050)
	Manila.........	15-59-04	1390			Dyce	6450
						Perth	6150
						Belgrade	7900
						Paris	(5800)
1246	No Location					Chicago	6450
Nov. 11							
1247	Strasbourg......	18-36-10	11380	φ = 5°·5 N	Manila gives	Ottawa	(8800)
Nov. 11	Wien...........	18-36-24	10450	λ = 124° E	SE. of Mindanao.	St. Louis	(1810)
	Osaka..........	18-35-38	3500	O = 18-36-27	Batavia gives	Toronto	(7960)
	Pola...........	18-37-14	9880		Menado; tide	Chicago	8450
	Honolulu.......	18-35-50	8500		waves at Great	Algiers	10180
	Lemberg........	18-37-21	9650		Sangi island.	Dyce	4400
	Zi-ka-wei.......	18-35-52	2750			Hamburg	9650
	Batavia.........	(18-36-56)	(2340)			Perth	2600
	Belgrade........	18-37-12	9580			Athens	8920
	Budapest.......	18-37-03	9340			Barcelona	8260
	Manila.........	(18-35-17)	(1520)			Coimbra	8500
	Paris...........		12000			De Bilt	(9600)
						Besançon	(9060)
						Naples	(7600)
1248	Washington.....	8-39-25	4000	φ = 4° N	De Bilt gives	St. Louis	2900
Nov. 13	Chicago........	8-39-22	4140	λ = 88° W	Nicaragua (?)	Strasbourg	(330)
	Balboa.........	8-41-01	880	O = 8-40·0		Cheltenham	2680
	La Paz.........	8-40-27	3190				

LOCATION OF EPICENTRES, 1921

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1249	Strasbourg......	20-36-28	4880	$\varphi = 40°$ N	Strasbourg gives	St. Louis 6110
Nov. 15	Algiers........	20-36-34	5530	$\lambda = 68°{\cdot}5$ E	region of	Victoria (7450)
	Pola...........	20-36-45	4370	O = 20-36-36	Samarkanda.	Osaka 6900
	Marseilles.......	20-36-44	5120		De Bilt gives	Tucson (3180)
	Firenze.........	20-36-33	4600		South Turkestan.	Honolulu 8880
	Hamburg.......	20-36-33	4620			Washington 7950
	Lemberg........	20-36-33	3590			Zi-ka-wei 3810
	Belgrade........	20-36-35	3900			
	Göttingen.......	20-36-34	4600			
	Höhenheim......	20-36-39	4660			
	Königsberg......	20-36-41	3810			
	München.......	20-36-32	4560			
	Barcelona.......	20-36-37	5440			
	Coimbra........	20-36-26	6480			
	Paris...........	20-36-37	5160			
	Naples..........	29-36-47	4480			
	Besançon.......	20-36-33	4980			
	De Bilt	20-36-31	4980			
	Ottawa.........	20-37-17	9010	$\varphi = 50°$ N	N.B.—Ottawa record has well-defined phases, so there can be no doubt of the values of O and Δ. Taking Ottawa, Chicago, Ithaca and Georgetown in conjunction with all the eastern stations listed on the left, the second location was determined.	
	Chicago.........	20-37-45	9000	$\lambda = 74°$ E		
	Ithaca..........	20-37·1	9250			
	Georgetown.....	20-37-44	9060			
1250	Ottawa.........	15-29-27	4620	$\varphi = 5°$ N		St. Louis (1780)
Dec. 18	Strasbourg......	15-29-21	8480	$\lambda = 67°{\cdot}5$ W		Victoria 1710
	Fordham........	15-29-28	4060	O = 15-29-26		Pola 8250
	Toronto.........	15-29-20	5000			Porto Rico 2140
	Dyce...........	15-29-33	8000			Rio de Janeiro 2900
	Georgetown	15-29-33	3850			Stonyhurst 2010
	Firenze.........	15-29-38	8420			La Paz 1170
	Cheltenham.....	15-29-45	3720			Honolulu 8280
	Tucson.........	15-29-07	5050			Batavia 7600
	Sitka...........	15-29-39	7680			Belgrade 8280
	Algiers.........	15-29-19	8000			Manila 8200
	Ithaca..........	15-29-47	4200			Naples (10740)
	Marseilles.......	15-29-28	8200			
	Hamburg.......	15-29-38	8360			
	Washington.....	15-29-45	3720			
	Chicago........	15-28-17	4450			
	Balboa.........	15-29-35	1430			
	Northfield......	15-29-14	4600			
	Barcelona.......	15-29-21	8000			
	Coimbra........	15-29-20	7220			
	Paris...........	15-29-21	8150			
	De Bilt........	(15-29-33)	(8280)			
	Besançon.......	15-29-33	8160			

DEPARTMENT OF THE INTERIOR
CANADA

HON. CHARLES STEWART, *Minister* W. W. CORY, C.M.G., *Deputy Minister*

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

R. MELDRUM STEWART, M.A., *Director*

Vol. VII

SEISMOLOGY

No. 3

The Location of Epicentres, 1922

BY

W. W. DOXSEE, M.A.

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1926

LOCATION OF EPICENTRES, 1922

In March, 1922, one Milne-Shaw horizontal seismograph was added to the equipment of the seismological station of the Dominion Observatory and a second of the same type was put in operation in December of the same year. These new instruments have resulted in a marked increase in the number of earthquakes recorded at Ottawa. With the installation of more sensitive seismographs at a large percentage of the other stations the amount and value of the data available for location work have been materially increased.

During the year 1922, one hundred and twenty earthquakes, serially numbered 1251 to 1370 inclusive, were recorded by the seismographs at this station. Utilizing all available data, determinations were made of the geographical co-ordinates for fifty-four of the epicentres, and, of the remaining sixty-six, twelve were roughly located either by Press reports or from the bulletins of one or more of the co-operating stations. The method followed, as well as the form of tabulating the results, has been consistently the same ever since the work was first undertaken in the year 1911. Readings given by the various stations are all reduced by means of the Klotz Tables, and the epicentres determined by means of the stereographic projection method. No attempt is made to use those records which do not give readings for P and S, from which to deduce the value of Δ and O, which, respectively, are the distance from the station to the epicentre, measured in kilometres, and the Greenwich Mean Time of the disturbance at its origin expressed in hours, minutes and seconds.

No doubt a much closer approximation to the epicentre should result if corrections were applied for estimated depth of focus, and "Shadow Zone" readings made use of in the case of distant earthquakes. Such detailed analysis cannot be undertaken at any one station for every earthquake. Probably for some time to come the programme at this station will include such a minute examination of only a few of the largest earthquake records in any one year. However, it is felt that these locations, which have been carefully and consistently calculated, will serve a useful purpose in seismological research.

DOMINION OBSERVATORY,
OTTAWA, CANADA,
June, 1926.

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1251	Coimbra........	14–11–26	8850	$\phi = 12° S$		Victoria (8020)
Jan. 6	Algiers........	14–13–47	8800	$\lambda = 61°{\cdot}5 W$		Stonyhurst 7960
	Wien..........	(14–12–21)	(9660)	O = 14–11–30		Belgrade 8050
	Cheltenham.....	14–11–40	5750			
	Pola...........	(14–12–08)	(9800)			
	Georgetown.....	14–10–59	6220			
	Washington.....	14–10–50	6240			
	Chicago........	14–11–07	6520			
	Balboa.........	14–10–40	3100			
	Hamburg........	(14–11·9)	(9900)			
	La Paz.........	14–10–14	1060			
	De Bilt........	(14–11–57)	(9650)			
	Uccle..........	14–11–29	9880			
	Berkeley.......	(14–10–38)	(8550)			
1252	Ottawa.........	5–09–32	3440	$\phi = 24°{\cdot}5 N$	De Bilt gives	Port-au-Prince 6450
Jan. 9	St. Louis......	(5–09–27)	(4450)	$\lambda = 47° W$	North Atlantic	
	Ithaca.........	5–09–13	3560	O = 5–09–26	Ocean.	
	Strasbourg.....	5–09–31	5310			
	Coimbra........	5–09–43	3600		Uccle gives	
	Algiers........	5–09–20	4860		$\phi = 33° N$	
	La Paz.........	5–09–39	4890		$\lambda = 57° W.$	
	Paris..........	5–09–33	4920			
	Wien...........	5–09–27	6110		Zürich gives	
	Toronto........	5–09–57	3330		$\phi = 24° N$	
	Pola...........	5–09–33	5950		$\lambda = 48° W$	
	Porto Rico.....	5–09–34	2210			
	Cheltenham.....	5–09–23	3280			
	Georgetown.....	5–09–05	3520			
	Dyce...........	5–09–22	5080			
	Washington.....	5–09–18	3400			
	Chicago........	5–09–26	4220			
	Stonyhurst.....	5–09·6	4880			
	Hamburg........	5–09–23	5740			
	Innsbruck......	5–09–34	5600			
	Königsberg.....	5–09–33	5250			
	Rio de Janeiro...	5–08–41	5580			
	Firenze........	5–09–06	5800			
	De Bilt........	5–09–32	5250			
	Göttingen......	5–09–26	5660			
	Barcelona......	5–09–19	4850			
	Belgrade.......	5–09–20	6540			
	Naples.........	5–09–43	6250			
	Uccle..........	5–09–22	5240			
	Besançon.......	5–09–28	5230			
	Zürich.........	5–09–32	5400			
	Berkeley.......	5–09–15	7700			

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1253	Ottawa.........	3-50-17	4780	$\phi = 4°\cdot5$ N.	Dr. Perry Byerly of	St. Louis	1090
Jan. 17	Saskatoon.......	3-50-22	6160	$\lambda = 66°\cdot2$ W	Berkeley, Cal. after	Osaka	9560
	Georgetown.....	3-50-16	4040	O = 3-50-30	analyzing seismo-	Victoria	1170
	Ithaca..........	3-50-32	4280		grams from many	Honolulu	8200
	Strasbourg......	3-50-16	8640		different stations,	Perth	7700
	Coimbra........	3-50-22	7250		concluded that	Helwan	2950
	Algiers.........	3-50-16	8090		there were three	Balboa	650
	Wien...........	3-50-55	8380		distinct quakes all	Belgrade	10520
	Paris...........	3-50-31	8100		happening within	Zi-ka-wei	7860
	Pola............	3-50-35	8850		6 seconds:	Stonyhurst	1490
	Dyce...........	(3-50-19)	(8200)		No. 1	Königsberg	8480
	Washington.....	3-50-21	4000		O = 3-50-20	Port-au-Prince	950
	Athens.........	3-50-35	8840		$\phi = 4° 35'\cdot2 \pm 32''$ S	La Paz	1360
	Northfield......	3-50-35	4400		$\lambda = 63° 56'\cdot3 \pm$	Rio de Janeiro	
	Naples.........	3-50-27	8100		$22''$ W		2900
	Uccle...........	3-50-32	8180		No. 2		
	Hamburg.......	3-50-39	8420		O = 3-50-22		
	Göttingen.......	3-50-45	8260		$\phi = 5° 11'\cdot5 \pm 5'$ N		
	Hohenheim.....	3-50-33	8520		$\lambda = 66° 45'\cdot2 \pm 4'$ W		
	Besançon.......	3-50-22	8450		No. 3		
	München.......	3-50-47	8350		O = 3-50-24		
	Barcelona.......	3-50-20	8080		$\phi = 3° 12'\cdot1 \pm 3'$ S		
	Rocca di Papa...	3-50-24	8840		$\lambda = 82° 50'\cdot2 \pm 3'$ W		
	Innsbruck.......	3-50-46	8300				
	Firenze.........	3-50-33	8600		Using La Paz and		
	De Bilt.........	(3-50-39)	(8320)		Rio de Janeiro in		
					conjunction with		
					those listed on the		
					left, gives an		
					indication of an		
					epicentre in agree-		
					ment with No. 1.		
					Uccle gives		
					$\phi = 4°$ N		
					$\lambda = 65°$ W		
1254	No Location....				Manila gives	Honolulu	5700
Jan. 19					North Mindanao	Perth	4600
						Manila	3120
						Uccle	(9400)
1255	No Location....					La Paz	9320
Jan. 22						Victoria	(2390)
						Honolulu	1770
						Perth	5950
						Belgrade	1330

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1256	No Location....					Honolulu 1730
Jan. 22						Perth 5180
						La Paz (8760)
						Belgrade 10250
1257	No Location....					Victoria 660
Jan. 26						Tucson 2050
1258	Ottawa.........	13–17–19	3900	ϕ = 41°.5 N	Press report of	Osaka 7460
Jan. 31	Saskatoon.......	13–17–06	2000	λ = 126°·8 W	quake in Pacific	Nagasaki (4200)
	Halifax.........	13–17–09	4940	O = 13–17–23	off Eureka, Cal.	Besançon (10850)
	Harvard........	13–16–59	4480			
	Toronto.........	13–17–19	3910		Uccle gives	
	St. Louis.......	13–17–16	2990		ϕ = 40° N	
	Fordham.......	13–17–23	4120		λ = 127° W	
	Ithaca..........	13–17–20	3910			
	Strasbourg......	13–17–42	8840		Zürich gives	
	Coimbra........	13–17–45	8820		ϕ = 40° N	
	Algiers.........	13–17–26	9750		λ = 125° W	
	La Paz.........	13–17–33	8750			
	Paris..........	13–17–35	8800		Berkeley and	
	Wien...........	13–17–30	9400		Lick give	
	Victoria........		880		ϕ = 41° 8′ ± 3′ N	
	Cheltenham.....	13–17–12	4020		λ = 125°30′ ± 3′W	
	Tucson.........	13–17–06	1830			
	Porto Rico......	13–17–28	6250			
	Honolulu.......	13–17–16	3680			
	Pola...........	13–17–08	9950			
	Georgetown.....	13–17–12	4080			
	Dyce...........	13–17–39	7800			
	Washington.....	13–17–15	4020			
	Ootomari.......	13–17–24	7140			
	Chicago........	13–17–07	3120			
	Lick...........	13–17–21	540			
	Northfield......	13–17–09	4280			
	Lemberg........	13–17–29	9440			
	Berkeley.......	13–17–21	960			
	Stonyhurst......	13–17·6	7960			
	Uccle..........	13–17–26	8820			
	Hamburg.......	13–17–28	8750			
	Zürich.........	(13–16–30)	9350			
	Innsbruck.......	13–17–39	9230			
	Firenze.........	13–16–55	10050			
	Göttingen......	13–17–27	8940			
	Athens.........	13–17–15	10140			
	Barcelona.......	13–18–05	9060			
	De Bilt.........	(13–17–29)	(8750)			
	Belgrade........	13–18–02	9600			
	Naples.........	13–17–47	9600			

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1259 Feb. 16	Ottawa.........	3-14-40	3720	ϕ = 11°·5 N	Press reports	Algiers (7320)
	St. Louis........	3-14-40	2990	λ = 85° W	quake at	Strasbourg 2700
	Porto Rico......	3-14-53	2220	O = 3-14-37	Nicaragua.	Fordham 4260
	Cheltenham.....	3-14-55	3720			Washington 2440
	Cartuja.........	3-14-36	8650			
	Wien...........	3-14-37	10050			
	Balboa.........	3-14-55	660			
	Chicago........	3-14-10	3360			
	Georgetown.....	3-14-39	3080			
	Coimbra........	3-13-41	7680			
	La Paz.........	3-14-57	3420			
1260 Feb. 19	No Location....					Cartuja (2960)
						Chicago 2520
						Coimbra (1750)
						La Paz 6680
1261 Feb. 20	No Location.....					Perth 8520
						La Paz (4200)
1262 Feb. 28	No Location....					Tucson 2030
1263 Mar. 4	St. Louis........	13-07-30	7700	ϕ = 56° N	Coimbra gives	Ottawa 6580
	Cartuja.........	13-08-05	8880	λ = 155° E	ϕ = 57°·6 N	Honolulu 4720
	Algiers.........	13-07-53	8940	O = 13-07-43	λ = 171° E	Perth 3720
	Wien...........	13-08-13	7200			Washington 7200
	Strasbourg......	13-07-38	8050		Zürich gives	Chicago 6400
	Hamburg.......	13-07-38	7500		ϕ = 53° N	Fordham 7100
	Helwan.........	13-07-52	8800		λ = 145° E	Northfield 6760
	Pola............	13-07-44	8200			Ootomari 910
	Athens.........	13-07-44	8520		Belgrade gives	Nagasaki 2500
	Paris...........	13-07-42	8100		Kamchatka	
	Georgetown.....	13-07-43	8160			
	Königsberg......	13-07-38	7020			
	Firenze.........	13-07-48	8300			
	Coimbra........	13-07-37	9160			
	Göttingen.......	13-07-40	7660			
	Barcelona.......	13-07-43	8840			
	Belgrade........	13-07-45	7980			
	Naples.........	13-07-48	8500			
	De Bilt.........	13-07-42	7720			
	Innsbruck.......	13-07-40	8080			
	Uccle...........	13-07-38	7880			
	Batavia........	13-07-44	7660			
	Besançon.......	13-07-45	8150			
	Zürich..........	13-07-38	8150			
	Berkeley........	13-07-09	6250			

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1264 Mar. 10	No Location....				Press report of quake felt at Los Angeles, Fresno, Bakersfield and San Luis Obispo, Cal. Berkeley and Lick report this quake in San Andreas Rift, east of Shandon, Cal. Union Oil Co. pipe line to San Luis Obispo broken in four places between Shandon and Antelope and between Cholame and Annette.	St. Louis 5880 Chicago 1930 Fordham (1790) Georgetown 3500
1265 Mar. 10	No Location....					Cartuja (8500) Algiers (3030) Strasbourg 1950 Chicago (2280) Pola 5550 Coimbra (10050) Belgrade 1670 Batavia 7250 La Paz 5900
1266 Mar. 12	Rio de Janeiro.. La Paz........	16–51–45 16–51–52	3240 2510	ϕ = 38° S λ = 73° W O = 16–51–48		Chicago (9980) Coimbra 10050
1267 Mar. 22	No Location....				St. Louis reports quake felt at Hickman and Paducah, Kentucky and at Poplar Bluff, Missouri.	Ithaca 260 Chicago 360 St. Louis 190

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1268	Ottawa.........	3-57-53	7280	ϕ = 19°·5 S	Coimbra gives	Toronto	7600
Mar. 28	Ithaca..........	3-57-54	6950	λ = 67°·5 W	ϕ = 19°·2 S	Algiers	9160
	Cartuja.........	3-58-02	9060	O = 3-57-55	λ = 67° W	Porto Rico	3900
	Honolulu.......		10700			Strasbourg	9400
	Tucson.........	3-57-54	7340		Zürich gives	Hamburg	9450
	Cheltenham.....	3-57-48	6480		ϕ = 16° S	Helwan	4250
	Washington.....		6500		λ = 53° W	Paris	9280
	Fordham........	3-57-57	6710			Zi-ka-wei	3000
	Northfield......	3-57-48	7180		Belgrade gives	Göttingen	9450
	Georgetown.....	3-57-51	6600		Tarapaco, Chile	Barcelona	(9120)
	Coimbra........	3-57-57	9010			Belgrade	(8680)
	Rio de Janeiro...	3-58-06	2340			De Bilt	(9350)
						Innsbruck	9350
						Uccle	9380
						Zürich	9400
1269	No Location....					Chicago	5520
April 2						La Paz	5320
1270	Ottawa.........	(19-17-06)	(6370)	ϕ = 53°·5 N	La Paz and	Toronto	2510
April 2	Wien...........	(19-17-28)	(9100)	λ = 165° W	Coimbra give	Georgetown	(8840)
	Ithaca..........	(19-17·8)	(6220)	O = 19-17-41	Aleutian Islands.	Ootomari	3200
	St. Louis......	19-17-50	5600				
	Victoria........	19-16-37	2410		De Bilt gives		
	Algiers.........	19-17-57	9660		Fox Islands.		
	Zi-ka-wei.......	19-17-50	6150				
	Hamburg.......	19-18-06	7960				
	Chicago........	19-17-43	5560				
	Königsberg.....	(19-17-26)	(8440)				
	Stonyhurst......	19-18·1	7850				
	Strasbourg......	(19-17-37)	(8920)				
	Paris...........	19-17-23	8300				
	Barcelona.......	(19-17-35)	(9480)				
	De Bilt.........	19-17-52	8250				
	Belgrade........	19-17-53	9050				
	Dyce...........	19-17-48	7600				
	Coimbra........	19-17-50	9340				
	Uccle..........	19-17-54	8360				
	Lick...........	19-17-52	3550				
1271	Ottawa.........		12700	ϕ = 7° N	De Bilt gives	Wien	(8650)
April 5	Zi-ka-wei.......	9-59-31	3750	λ = 148°·5 E	"In or near New	Toronto	(8680)
	Osaka..........	10-00-16	3400	O = 9-59-15	Guinea."	Victoria	6860
	Manila.........	9-58-34	3070			Hamburg	(11000)
	Nagasaki.......	9-58-41	3730			Chicago	(10620)
						Perth	7700
						Strasbourg	(8200)
						Uccle	(8180)
						La Paz	14000

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1272	Coimbra........	3-13-26	8820	ϕ = 10°·5 S		Chicago (4050)
April 6	La Paz.........	3-13-02	1000	λ = 75° W		
				O = 3-13-14		
				Location		
				doubtful.		
1273	Coimbra........	8-01-23	8840	ϕ = 10°·5 S		Chicago (4260)
April 6	La Paz.........	8-00-45	1010	λ = 75° W		
				O = 8-01-04		
				Location		
				doubtful.		
1274	Ottawa.........	20-42-14	4450	ϕ = 72° N	Hamburg gives	Ithaca 3120
April 8	Wien...........	20-41-35	3330	λ = 8°·5 W	Jan Mayen	St. Louis (2900)
	Lemberg........	20-42·1	3070	O = 20-42-15		Toronto 4020
	Athens.........	20-42-26	4000		Uccle gives	Victoria 2820
	Algiers.........	20-41-52	4150		ϕ = 70° N	Washington 5740
	Zi-ka-wei.......	20-42-21	8200		λ = 20° W	Potsdam 3240
	Hamburg.......	20-42-24	2200			La Paz 11220
	Georgetown.....	20-42-11	5320		Zürich gives	
	Chicago........	20-42-21	5160		ϕ = 71°·8 N	
	Cheltenham.....	20-42-37	4950		λ = 8°·9 W	
	Königsberg.....	20-42-30	2250			
	Helwan.........	20-42-17	5300			
	Göttingen.......	20-42-04	2510			
	Hohenheim.....	20-42-01	2780			
	München.......	20-41-58	2990			
	Innsbruck.......	20-42-40	2660			
	Barcelona.......	20-42-20	3120			
	De Bilt.........	20-42-16	2330			
	Strasbourg......	20-42-08	2810			
	Paris...........	20-42-14	2620			
	Belgrade........	20-42-28	3070			
	Naples.........	20-42-02	3800			
	Dyce...........	20-42-38	1480			
	Coimbra........	20-42-06	3550			
	Uccle..........	20-42-09	2500			
	Besançon.......	20-42-21	2770			
	Zürich..........	20-42-01	2970			
	Berkeley........	20-42-36	6860			
1275	No Location....					Victoria 3200
April 11						Zi-ka-wei 6780
						Chicago (4080)
						Perth 7690
						Strasbourg 1800
						La Paz 11460

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1276	No Location....					Zi-ka-wei 6950
April 11						
1277	No Location....					St. Louis 2750
April 13						Georgetown (2610)
1278	No Location....					No data.
April 17						
1279	Chicago........	5–48–19	3190	ϕ = 15° N	Press reports	
April 20	La Paz.........		3800	λ = 90° W	quake in	
				O = 5–48–19	Guatemala.	
1280	No Location....					Wien (8000)
April 25						Zi-ka-wei 6550
						Chicago 8440
						Perth 5700
						Innsbruck 1710
1281	Zi-ka-wei.......	1–11–30	1720	ϕ = 36°·5 N	Nagasaki reports	Wien 7800
April 26	Manila.........	1–11–38	2950	λ = 138°·5 E	quake near	Honolulu 2720
	Uccle..........	1–11–39	9230	O = 1–11–36	Kisarazu.	
	Ootomari.......		850			
	Nagasaki.......		900			
1282	Wien..........	3–58–57	9120	ϕ = 45° N		Osaka 5200
April 26	Königsberg.....	3–59–05	8060	λ = 152°·5 E		Honolulu 4080
	Lemberg........		9300	O = 3–59–08		Chicago (5620)
	Zi-ka-wei.......	3–59–03	3120			Stonyhurst 3000
	Strasbourg......	3–59–11	8920			
	Uccle..........	3–59–09	8900			
	De Bilt........	(3–59–18)	(8680)			
	Innsbruck......	3–59–14	9010			
	Ootomari.......		725			
	Nagasaki.......		2300			
1283	No Location....					No data.
April 28						
1284	No Location....					No data.
April 28						
1285	No Location....					No data.
May 1						
1286	Ottawa.........	4–00–23	6620	ϕ = 50° N		
May 3	Zi-ka-wei.......	4–00–11	5900	λ = 170°·5 W		
				O = 4–00–17		
				Location only		
				approximate.		

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1287 May 4	Ottawa.........	9-12-59	8680	ϕ = 45°·5 N	Manila, Tokio,	Lemberg	9780
	Paris..........	9-12-59	9020	λ = 154°·2 E.	De Bilt and		
	Honolulu.......	9-12-45	5100	O = 9-12-59	Zürich give		
	Strasbourg......	9-12-52	9000		Kurile Islands.		
	Hamburg.......	9-12-56	8420				
	Helwan.........	9-13-16	9280				
	Washington.....	9-13-58	8800				
	Chicago........	9-12-53	8520				
	Belgrade........	9-12-41	9160				
	Wien...........	9-12-18	9480				
	Uccle...........	9-12-48	8900				
	Königsberg.....	(9-13-28)	(7320)				
	De Bilt.........	9-12-58	8720				
	Batavia.........	9-12-56	7400				
	Tokio..........	9-12-56	1610				
	Ootomari.......		700				
	Nagasaki.......	9-12-52	2460				
	Berkeley........	9-13-17	6480				
1288 May 5	No Location....					Belgrade	9400
						Wien	8000
						Tokio	540
						Ootomari	600
1289 May 11	No Location....					La Paz	3600
						Chicago	(5800)
1290 May 11	Ottawa.........	6-45-25	4000	ϕ = 11° N	Port au Prince and	Belgrade	3440
	La Paz.........	6-45-32	3050	λ = 60° W	Coimbra give		
	Algiers.........	6-45-30	6860	O = 6-45-33	Martinique.		
	Hamburg.......	6-45-35	7660				
	Chicago........	6-45-08	4400				
	Washington.....	6-46-07	3410				
	Georgetown.....	(6-45-28)	(3400)				
	Ithaca..........	6-45·2	3910				
	Coimbra........	6-45-34	5870				
	Wien..........	6-45-38	8000				
	Uccle..........	6-45-32	7220				
	De Bilt.........	6-45-50	7150				
1291 May 11	No Location....					Zi-ka-wei	7450
						Perth	4120
						Belgrade	13000

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1292	Honolulu.......	18–39–16	6120	ϕ = 23°·5 S	De Bilt gives	La Paz	8840
May 12	Zi-ka-wei.......	18–39–35	7800	λ = 170°·5 E	Pacific Ocean	Fordham	3600
	Batavia.........	18–39–19	7100	O = 18–39–24	near New Cale-	Algiers	10000
	Berkeley........	18–39–28	9700		donia	Strasbourg	11460
						Cartuja	12740
						Helwan	(2230)
						Perth	7040
						Belgrade	11920
						Coimbra	10180
1293 May 14	No Location....					No data.	
1294 May 22	No Location....					Balboa	160
1295 May 28	No Location....					No data.	
1296 May 28	No Location....					No data.	
1297	Zi-ka-wei.......	20–11–41	2640	ϕ = 8° N	Belgrade,	Algiers	(8800)
June 2	Manila.........	20–10–59	1480	λ = 126°.5 E	Manila, Tokio	Helwan	9300
	Wien...........	(20–11–43)	(10800)	O = 20–11–36	and Nagasaki	Coimbra	10600
	Königsberg......	(20–11–52)	(10220)		give Mindanao.	Honolulu	9520
	Batavia.........	20–11–43	2660			Washington	(8280)
	Melbourne......	20–11·6	5320			Chicago	8840
	Nagasaki.......		2564			Cartuja	(12080)
						Belgrade	8910
						Dyce	4500
						Uccle	(6900)
						Tokio	1640
1298 June 3	No Location....					No data.	
1299	Zi-ka-wei.......	4–56–32	1930	ϕ = 34° N			
June 3	Tokio..........	4–56–28	170	λ = 140°·5 E			
	Osaka..........		460	O = 4–56–30			
1300 June 4	No Location....					Manila	410
1301 June 8	No Location....					No data.	

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1302	Ottawa........	4-47-27	3750	ϕ = 32° N	De Bilt gives	Stonyhurst 5440
June 12	Fordham.......	4-47-20	3720	λ = 114°·5 W	Western North	Honolulu 5080
	Denver........	4-47-39	830	O = 4-47-49	America	Port-au-Prince
	St. Louis........	4-47-44	2360			1540
	Algiers.........	4-47-56	9880			Cartuja 8150
	Toronto........	4-48-15	3330			Dyce 7700
	Coimbra........	4-48-27	8800			Tucson 1210
	Cheltenham.....	4-47-14	3500			Lemberg 8800
	Porto Rico......	4-47-15	4520			Wien 9220
	Paris...........	4-48-24	9050			
	Strasbourg......	4-48-58	9050			
	Washington.....	4-47-23	3360			
	Chicago........	4-47-23	2820			
	Balboa.........	4-46-58	4400			
	Georgetown.....	4-47-22	3400			
	Belgrade........	4-47-22	10400			
	Ithaca..........	4-47-17	3580			
	Uccle...........	4-48-00	9280			
	De Bilt.........	4-48-23	9020			
	La Paz.........	4-47-44	6180			
	Besançon.......	(4-48-32)	(9280)			
1303	St. Louis........	10-42-33	2690	ϕ = 17° N		Coimbra 8800
June 12	Tucson.........	10-42-21	1660	λ = 111°·8 W		Washington 2880
	Cartuja.........	10-42-14	10400	O = 10-42-22		Chicago 2850
	La Paz.........	10-42-21	6040			Zi-ka-wei 8480
	Strasbourg......	(10-41-08)	(11050)			
1304 June 16	No Location....					No data.
1305 June 16	No Location....					No data.
1306	St. Louis........	20-58-09	3070	ϕ = 44°·5 N		Tucson 340
June 16	Victoria........		520	λ = 126° W		
	Cheltenham.....	20-59-07	3840	O = 20-58-47		
	Honolulu.......	20-59-05	3960	Location approximate only.		
1307	Strasbourg......	(14-29-48)	(11300)	ϕ = 7°·5 N	De Bilt gives	Chicago (8420)
June 27	Honolulu.......	14-29-54	8100	λ = 127° E	origin in or near	Manila 1700
	Zi-ka-wei.......	14-30-14	2720	O = 14-29-55	E. Mindanao	La Pas (15570)
	Batavia.........	(14-29-46)	(2650)			Tokio 4820

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1308 July 2	Ottawa.........	13-35-56	5640	ϕ = 54°·5 N	De Bilt and Zürich give Pacific Ocean south of Alaska.	Toronto	4450
	Algiers.........	13-36-01	9660	λ = 160° W		Tucson	5440
	Hamburg.......	13-35-57	8020	O = 13-36-02		Georgetown	(5080)
	Osaka..........	13-35-54	5250			Lemberg	7480
	Honolulu.......	13-35-49	3560			Wien	(7400)
	Paris...........	13-36-03	8450			Innsbruck	8000
	Coimbra........	13-36-01	9160			Belgrade	7900
	Strasbourg......	13-35-55	8600			Besançon	(9200)
	Cartuja.........	13-36-02	9550			Berkeley	3330
	St. Louis........	13-35-59	5320				
	Zi-ka-wei.......	13-35-51	6540				
	Manila.........		(7950)				
	Washington.....	13-36-36	6320				
	Chicago........	13-35-59	5180				
	Ithaca..........	13-36-·2	5650				
	Dyce...........	13-35-19	8000				
	Uccle...........	13-36-17	7900				
	Königsberg.....	13-35-58	7850				
	Barcelona.......	13-36-02	9200				
	De Bilt.........	13-36-05	8080				
	Agram..........	13-36-07	8800				
	La Paz.........	(13-36-17)	(11720)				
	Tokio..........	13-36-41	4850				
	Zürich.........	13-35-54	8750				
1309 July 2	No Location....				Press report of quake felt in the Maritime Prov'ces.	Georgetown	(1330)
1310 July 4	No Location....					Manila	600
1311 July 5	No Location....				Probably Kurile or Aleutian Is.	Uccle	8360
						Agram	(8800)
1312 July 10	Ottawa.........	9-38-00	6380	ϕ = 10° S	De Bilt gives West Brazil.	Strasbourg	8360
	Algiers.........	9-38-14	8050	λ = 61° W		Agram	8220
	Coimbra........	9-38-06	7720	O = 9-38-02		Zürich	8360
	Cartuja.........	9-37-52	7960	Location			
	Chicago........	9-38-03	6200	approximate			
	Ithaca..........	9-37-59	6080	only.			
1313 July 13	Coimbra........	(4-56-16)	(12950)	ϕ = 7° N	Manila gives Mindanao.	Tokio	2800
	Helwan.........	4-58-06	9940	λ = 124°·5 E		Manila	2320
	Zi-ka-wei.......	4-57-55	2620	O = 4-58-04			
	Batavia.........	4-58-11	2410				
1314 July 25	No Location..,					No data.	
1315 July 26	No Location....					Ottawa	(1970)

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1316 Aug. 9	No Location....					No data.	
1317 Aug. 11	Ottawa.........	(8-19·6)	(8360)	ϕ = 35°·5 N	Strasbourg gives	Georgetown	9300
	Algiers.........		2110	λ = 28° E	ϕ = 34° N,	Dyce	2760
	Helwan.........	8-19-47	640	O = 8-19-39	λ = 30° E	Wien	3030
	Coimbra........	8-19-55	2960			Chicago	(8520)
	Paris...........	8-19-36	2510		Zürich gives		
	Strasbourg......	8-19-34	2210		origin as near		
	Athens.........	8-19-20	580		Rhodes off SW.		
	Hamburg.......	8-19-34	2440		coast of Asia		
	Cartuja.........	8-19-55	2680		Minor.		
	Lemberg........	8-19-49	1680				
	Barcelona.......	8-19-33	2320		De Bilt gives		
	Belgrade	8-19-52	1030		Mediterranean Sea		
	Innsbruck.......	8-19-41	1880		near Asia Minor.		
	De Bilt.........	8-19-30	2590				
	Königsberg.....	8-19-22	2360				
	Agram..........	8-19-33	1570				
	Besançon.......	8-19-44	2200				
	Uccle...........	8-19-36	2490				
	Zürich..........	8-19-39	2035				
1318 Aug. 11	Algiers.........	13-38-11	9600	ϕ = 57°·5 N		Toronto	(6220)
	Victoria........	13-37-54	2070	λ = 151° W		Honolulu	3400
	Cartuja.........	13-39-24	9020	O = 13-38·5		Chicago	(5200)
	Hamburg.......	(13-39-31)	(7020)			Ithaca	(7380)
	Dyce...........	(13-38-39)	(6720)			Ootomari	2650
	Wien...........	13-38-23	8120				
	Agram..........	13-38-18	8400				
	Uccle...........	13-37·9	8260				
1319 Aug. 13	Ottawa.........	0-09-58	8200	ϕ = 35° N	Strasbourg gives	Tokio	4610
	Algiers.........	0-10-02	2100	λ = 27°·5 E	ϕ = 35° N	La Paz	9200
	Helwan.........	0-10-00	650	O = 0-09-55	λ = 31° E	Georgetown	9580
	Coimbra........	0-10-05	2990				
	Paris...........	0-09-58	2440		Innsbruck, Zürich		
	Strasbourg.....	0-09-53	2140		and Wien give		
	Athens.........	0-09-56	435		Asia Minor.		
	Hamburg.......	0-10-01	2300				
	Cartuja.........	0-09-52	2770		Belgrade, Uccle		
	Chicago........	(0-10-39)	(8720)		and De Bilt give		
	De Bilt.........	0-09-48	2540		Ægean Sea		
	Dyce...........	0-09-06	3380				
	Lemberg........	0-09-57	1690		Helwan reports		
	Wien...........	0-09-56	1670		quake felt		
	Königsberg......	0-09-49	2210		throughout Egypt.		
	Barcelona.......	0-09-46	2340				
	Agram..........	0-09-56	1480				
	Innsbruck.......	0-09-56	1880				
	Belgrade........	0-10-01	1150				
	Besançon.......	0-09-48	2220				
	Uccle...........	0-09-37	2550				
	Zürich..........	0-10-01	1980				

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1320	Ottawa.........	15–56–27	7860	ϕ = 53° N	Zürich gives		
Aug. 16	Algiers.........	15–56–20	9940	λ = 158° E	ϕ = 54° N		
	Helwan.........	15–56–29	9480	O = 15–56–30	λ = 157° E		
	Coimbra........	15–56–36	9480				
	Honolulu........	15–55–58	5080		Coimbra gives		
	Strasbourg......		8200		Bering Sea.		
	Paris...........	15–56–34	8440				
	Zi-ka-wei.......	15–56–22	3740		Hamburg, De Bilt,		
	Cartuja.........	15–56–35	9750		Tokio, Innsbruck		
	Georgetown.....	15–56–11	8800		and Nagasaki give		
	Hamburg.......	15–56–45	7660		Kamchatka.		
	De Bilt.........	15–56–36	8060				
	Chicago........	15–56–24	7660		Belgrade and		
	Lemberg........	15–56·5	7960		Uccle give		
	Wien...........	15–56–49	7920		Aleutian Is.		
	Osaka..........	15–56–03	2800				
	Königsberg......	15–56–29	7450				
	Barcelona.......	15–56–32	9300				
	Agram..........	15–56–35	8440				
	Tokio..........	15–56–46	2290				
	Batavia.........	(15–56–29)	(8200)				
	Innsbruck.......	15–56–40	8350				
	Belgrade........	15–56–36	8380				
	Uccle...........	15–56–31	8250				
	Zürich..........	15–56–36	8450				
	Nagasaki.......	15–56–40	2970				
1321	No Location....				Berkeley reports	Berkeley	240
Aug. 18					quake felt at	Lick	180
					Fresno and Bakers-		
					field, California.		
1322	Strasbourg......	11–46–54	1700	ϕ = 37° N	Zürich, De Bilt	Honolulu	5700
Aug. 25	Barcelona.......	(11–47–27)	(500)	λ = 3° E	and Innsbruck	Coimbra	460
	Innsbruck.......	11–47–52	1250	O = 11–47–25	give Algiers.	Königsberg	(1350)
	Zürich..........	11–47–27	1340	Location		Melbourne	3520
				approximate.			
1323	Ottawa.........	19–29–55	9200	ϕ = 51° N	De Bilt gives	Honolulu	10150
Aug. 25	Algiers.........	19–29–38	6920	λ = 93°·5 E	in or near	Hamburg	4800
	Coimbra........	19–29–30	7480	O = 19–29–39	NW. Mongolia	Lemberg	10750
	Paris...........	(19–29–40)	(6000)			Wien	7250
	Cartuja.........	19–29–28	7600		Zürich gives	Belgrade	13200
	De Bilt.........	19–29–47	5530		Central Asia	Ootomari	1110
	Königsberg......	(19–29–56)	(4200)		N. of Irkutsk	Nagasaki	4000
	Agram..........	19–29–32	5380				
	Uccle...........	19–29–28	5850				

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1324	Zi-ka-wei	17-00-57	2170	ϕ = 12° N	Manila gives	Coimbra (7550)
Aug. 29	Osaka	17-01-43	2700	λ = 124° E	Tablas I.	Hamburg (9900)
	Batavia	17-00-48	2720	O = 17-01-09		Agram 9280
	Nagasaki	17-01-08	2340		Tokio, De Bilt	Tokio 2580
					and Nagasaki	
					give Philippine	
					Is.	
1325	No Location....					Chicago 1430
Aug. 30						
1326	Paris	19-16-30	9340	ϕ = 25° N	Uccle gives	Ottawa 8180
Sept. 1	St. Louis	19-16-42	11620	λ = 120° E	ϕ = 27° N	Algiers (12580)
	Cheltenham	19-16-34	12600	O = 19-16-10	λ = 123° E	Toronto (8550)
	Sitka	19-15-51	8700			Victoria 2800
	Honolulu	19-15-54	8360		Strasbourg,	Cartuja 7800
	Strasbourg	19-15-50	9900		Manila, Naples	Washington (8520)
	Helwan	(19-16-09)	(8740)		and Zürich give	Chicago 8380
	Hamburg	19-16-10	9120		Formosa.	Georgetown 9900
	Athens	19-16-06	9050			Coimbra 10050
	Manila	19-16-01	1100			Ithaca 8350
	Lemberg	19-16-08	8700			Königsberg 9700
	Wien	19-16-09	9060			Berkeley 9380
	Dyce	19-16-17	9350			Ootomari 2690
	De Bilt	19-16-10	9480			
	Osaka	19-15-58	1750			
	Melbourne	19-15·8	7380			
	Batavia	19-16-33	3240			
	Belgrade	19-16-02	9080			
	Innsbruck	19-16-25	9080			
	Besançon	19-16-18	9560			
	Naples	19-16-20	9300			
	Uccle	19-16-10	9560			
	Zürich	19-16-06	9600			
	Nagasaki	19-15-56	1290			
1327	No Location....					Georgetown (1610)
Sept. 3						
1328	Algiers	17-08-56	5450	ϕ = 24° N	Uccle gives	Cartuja 7680
Sept. 4	Paris	17-09-10	5520	λ = 52° W	ϕ = 24° N	Washington 5720
	Strasbourg	17-08-53	5820	O = 17-09-05	λ = 51° W	Coimbra 7530
	Chicago	17-08-25	3140			Wien (11050)
	Hamburg	17-09-32	5660		De Bilt gives	La Paz 590
	Barcelona	17-09-03	5440		Atlantic Ocean.	Zürich 8260
	Dyce	17-09-12	5520			Berkeley 6710
	Besançon	(17-09-01)	(5720)			
	De Bilt	17-09-24	5550			
	Uccle	17-09-18	5550			

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1329 Sept. 4	No Location....					Manila Nagasaki	1860 1240
1330 Sept. 11	No Location....					La Paz	3600
1331 Sept. 12	No Location....					Chicago	5100
1332 Sept. 14	Strasbourg...... Helwan......... Hamburg....... Manila......... Wien........... Osaka.......... Königsberg...... Uccle........... Zürich..........	19–31–55 19–31–57 19–31–33 19–31–35 (19–31–53) 19–31–48 19–31–43	9450 8620 9250 1200 9150 1700 (8380) 9520 9560	ϕ = 25° N λ = 121° E O = 19–31–46	Manila and Zürich give Formosa.	Victoria Honolulu Coimbra Belgrade Melbourne Ootomari Nagasaki	4660 5300 (11980) 12820 6550 3335 1670
1333 Sept. 16	Helwan......... Wien........... Manila......... Osaka..........	22–44–54 22–44–27	8680 9340 1100 1700	ϕ = 24°·5 N λ = 121°·8 E O = 22–44–40	Manila gives NE. Formosa	Coimbra Ootomari Nagasaki	8250 4507 1550
1334 Sept. 17	No Location....				Manila gives N. Formosa.	Honolulu Helwan Manila Coimbra Osaka Nagasaki	(5200) 8320 1800 8550 1800 1530
1335 Sept. 17	Helwan......... Wien........... Manila......... Osaka..........	9–59–30 9–59–31	8650 9000 1500 1680	ϕ = 25°·5 N λ = 121°·8 E O = 9–59–30	Manila gives N. of Formosa	Honolulu Coimbra Nagasaki	5200 (7400) 1620
1336 Sept. 29	No Location....					No data.	
1337 Sept. 29	No Location....					Washington Chicago	(5310) 2930
1338 Sept. 30	No Location....					No data.	

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1339	Ottawa.........	5-28-11	5240	ϕ = 65°·5 N		Georgetown (2380)
Oct. 6	Cartuja.........	5-28-35	8400	λ = 159°·5 W		
	Washington.....	5-29-07	5820	O = 5-28·8		
	Chicago........	5-28-54	5750	Location		
	Uccle...........	(5-29·3)	(6800)	doubtful.		
1340	No Location....					No data.
Oct. 7						
1341	Ottawa.........	14-49-40	6880	ϕ = 16°·2 S	Zürich gives	Helwan 9380
Oct. 11	St. Louis........	14-49-50	6240	λ = 72° W	ϕ = 16° S	Chicago 5870
	Algiers.........	14-50-09	9380	O = 14-49-50	λ = 73° W	Hamburg 9480
	Porto Rico......	14-49-51	3620			Dyce 9400
	Honolulu.......	14-50-01	9900		Hamburg, Coimbra	Wien 9520
	Rio de Janeiro..	14-50-37	2900		La Paz, Besançon,	Manila (9900)
	Washington.....	14-49-49	6040		Naples and Uccle	Belgrade 4500
	Balboa.........	14-49-21	3070		give Peru.	Besançon 9320
	Northfield......	14-49-48	6680			De Bilt 9420
	Barcelona.......	14-49-42	9350			Naples 9400
	Ithaca..........	14-49-43	6520			Uccle 9440
	Coimbra........	14-49-49	9050			Zürich 9420
	Cartuja.........	14-49-48	9300			Wellington 9400
	Georgetown.....	14-49-47	6150			
	La Paz.........		430			
1342	No Location....					No data.
Oct. 14						
1343	Hamburg.......	(23-46-54)	(9120)	ϕ = 24° N	Zürich and	Chicago (7500)
Oct. 14	Coimbra........	23-45-13	11200	λ = 121·5 E	De Bilt give	Ootomari 4300
	Wien...........	23-46-52	9060	O = 23-46-40ca	Formosa	
	Osaka..........		1760			
	Königsberg.....	23-46-56	8480			
	Besançon.......	23-45-59	10220			
	De Bilt.........	23-46-56	9340			
	Nagasaki.......		1200			
	Uccle...........	23-47·2	9280			
	Zürich.........	23-46-56	9650			
1344	Helwan.........	16-01-18	5440	ϕ = 41°·5 N	Zürich gives	Coimbra (7550)
Oct. 16	Wien...........	16-01-24	5840	λ = 92°·7 E	neighbourhood of	Manila 5220
	Dyce...........	16-01-46	4660	O = 16-01-24	Himalayas	Ootomari 304
	Königsberg.....	16-01·4	5320	Location		
	Belgrade........	16-01-04	5800	approximate.		
	Uccle...........	16-01-25	6570			
	Zürich.........		(6000)			

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data	
1345	No Location....				Nagasaki gives	Wien	8900
Oct. 17					Taiwan.	De Bilt	8900
						Nagasaki	1000
					De Bilt gives		
					Bay of Bengal		
					(Andaman I.).		
1346	Ottawa.........	21-22-03	8050	ϕ = 49° N	Zürich gives	Melbourne	8800
Oct. 24	Algiers.........	21-21-49	9080	λ = 152°·5 E	ϕ = 47° N	Wellington	8320
	St. Louis........	21-22-22	7760	O = 21-21-27	λ = 153° E		
	Sitka...........	21-20-54	4750				
	Honolulu.......	21-20-56	5200		Uccle gives		
	Toronto.........	(21-22-59)	(7960)		ϕ = 50° N		
	Helwan.........	21-21-24	9100		λ = 159° E		
	Athens.........	21-21-13	9000				
	Wien...........	21-21-14	8380		Coimbra gives		
	Georgetown.....	21-21-26	8950		ϕ = 52°·5 N		
	Cartuja.........	21-21-20	9950		λ = 159° W		
	Coimbra........	21-21-21	9420				
	Dyce...........	21-21-09	8060		Cartuja and		
	Ithaca.........	21-21-48	8400		De Bilt give		
	Hamburg.......	21-21-10	8120		Kurile Is.		
	Washington.....	21-22-36	8880				
	Chicago........	21-23-14	7850		Strasbourg and		
	Northfield......	21-22-08	8300		Naples give		
	Osaka..........		1780		Kamchatka.		
	Königsberg......	21-21-12	7580				
	Stonyhurst......	21-21·0	8440				
	Belgrade........	21-21-19	8480				
	Batavia.........	21-21-08	7220				
	Innsbruck.......	21-21-12	8680				
	Barcelona.......	21-21-13	9480				
	Besançon.......	21-21-27	8720				
	De Bilt.........	21-21-12	8400				
	Naples.........	21-20-52	9200				
	Uccle..........	21-21-13	8520				
	Ootomari.......		624				
	Zürich..........	21-21-13	8740				
	La Paz.........		14770				
1347	Wien...........	(14-22-21)	(9520)	ϕ = 26° N	De Bilt reports	Stonyhurst	4780
Oct. 27	Osaka..........		1730	λ = 122° E	quake felt at		
	Manila.........		1350	O = 14-22·8	N. Formosa.		
	De Bilt.........	14-22-53	9350	Location			
	Uccle..........	14-23·2	9280	approximate.			
1348	No Location....					No data.	
Oct. 30							

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1349 Oct. 30	No Location....					No data.
1350 Nov. 4	No Location....					No data.
1351 Nov. 7	Ottawa.........	23–00–23	8060	φ = 27° S	De Bilt gives	Helwan (8600)
	Algiers.........	23–00–58	9550	λ = 73° W	Pacific Ocean	Honolulu 6120
	Cartuja.........	23–00–33	9750	O = 23–00–23	near Chile.	Toronto (10880)
	Chicago........	23–00–20	7750			Wien (8200)
	Washington.....	23–00–12	7420			Stonyhurst 9280
	Northfield......	23–00–18	8020			De Bilt (9550)
	Rio de Janeiro..	23–00–17	2980			
	Georgetown.....	23–00–18	7400			
	Victoria........	23–00–18	9480			
	Coimbra........	23–00–37	9000			
	La Paz.........	23–00–19	1320			
	Wellington......	23–00·0	10050			
1352 Nov. 8	No Location....				De Bilt gives	Cartuja 7080
					Atlantic Ocean	Algiers 5040
					off Ascension I.	Coimbra 6520
						De Bilt 6800
1353 Nov. 11	Ottawa.........	4–32–37	8230	φ = 28°·7 S	Dr. Gutenberg	Denver 7600
	Halifax.........	4–32–58	8200	λ = 72° W	gives	Dyce 9980
	Algiers.........	4–33–14	9750	O = 4–32–48	φ = 29°·5 S	Lemberg 10050
	Paris...........	4–33–20	10250		λ = 71°·6 W	Zi-ka-wei 10640
	Cartuja.........	4–32–54	9800		O = 4–32–17	Athens 9280
	Strasbourg......	4–33–05	10650			Manila (17000)
	Ithaca..........	4–32–36	7900			Zürich (10060)
	Chicago........	4–32–52	7750		Tokio gives	Innsbruck 10120
	Honolulu.......	4–33–20	10050		φ = 27° S	Nagasaki 10000+
	Tucson.........	4–32–33	8120		λ = 71° W	Wellington 8900
	Cheltenham.....	4–32–46	7320			Ootomari 17597
	Porto Rico......	4–32–34	5050		Manila, Naples	
	Sitka...........	4–32–38	10950		Nagasaki and	
	Washington.....	4–32–34	7560		Coimbra give	
	Balboa.........	4–32–15	4370		Chile.	
	Victoria........	4–33–00	9900			
	Firenze.........	4–33–25	10260		Zürich reports	
	Wien...........	4–32–02	12700		quake felt at	
	Coimbra........	(4–32–23)	(9780)		La Serena,	
	Osaka..........		17000		Copiapo, Vallinar	
	Stonyhurst......	4–33·3	10180		and Coquimbo,	
	Uccle..........	4–33–13	10420		Chile.	
	Sydney.........	4–31–01	11460			
	Belgrade........	4–32–37	10980		De Bilt reports	
	Barcelona.......	4–32–48	10140		tidal wave at	
	Besançon.......	4–33–15	10350		Coquimbo, Chile.	
	De Bilt.........	4–33–23	10350			

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1354	Ottawa.........	18-09-33	8080	ϕ = 27° S	Press despatches	Strasbourg 10050
No. 11	Cartuja.........	18-09-34	9980	λ = 71° W	of shocks felt	Algiers 9500
	Rio de Janeiro..	18-09-13	2900	O = 18-09-34	in Chile in	Helwan (8500)
	Georgetown.....	18-09-27	7480		neighbourhood of	Toronto (6780)
	Washington.....	18-09-30	7420		Antofagasta	Coimbra 8880
	Chicago.........	18-09-40	7700			Stonyhurst 4880
	Victoria.........	18-09-36	9820			Uccle 9400
	La Paz..	18-09-57	1160			
1355	No Location....					Rio de Janeiro 3150
Nov. 12						Victoria 4780
1356	Ottawa.........	11-03-15	8020	ϕ = 27° S	Press despatch	Strasbourg 11000
Nov. 17	Ithaca..........	11-03-11	7720	λ = 77°·3 W	of shocks felt at	Algiers (9400)
	Cartuja.........	11-03-30	9880	O = 11-03-03	Copiapo and	Helwan (8450)
	Chicago.........	11-03-37	7580	Location	Vallinar, Chile.	Honolulu 5920
	Georgetown.....	11-02-04	7560	approximate.		Washington 8800
	Balboa.........	11-03-05	3960		De Bilt gives	Toronto (7480)
	La Paz.........	11-02-36	1490		"Origin near	Victoria 9080
					Chile."	
1357	No Location....					No data
Nov. 22						
1358	No Location....				De Bilt gives	Coimbra 10050
Dec. 2					N. Formosa.	Osaka 1760
						De Bilt 9380
						Nagasaki 1400
1359	Cartuja.........	13-53-43	8050	ϕ = 36° N	Zürich gives	Strasbourg (5000)
Dec. 6	Algiers.........	13-53-48	7280	λ = 76°·5 E	ϕ = 37° N	Victoria 2760
	Dyce...........	13-54-08	6820	O = 13-53-58	λ = 70° E	Firenze 4660
	Coimbra.........	13-54-11	7860			Chicago (7550)
	Lemberg.........	13-54·1	4880		De Bilt gives	Athens (550)
	Wien...........	(13-54-06)	(5420)		Pamir.	Königsberg (4500)
	Osaka.........		5750			Stonyhurst 5320
	Barcelona.......	(13-53-53)	(7150)			La Paz 1310
	Innsbruck.......	13-53-50	(6150)			De Bilt 5050
						Ootomari 3428
						Naples 2400
						Zürich (5000)
1360	No Location....					Manila 630
Dec. 13						
1361	No Location....					Ottawa 8800
Dec. 14						Honolulu (4860)
						Algiers 8840
						Victoria 5150
						Osaka 4300
						Perth 3800
						Uccle (10900)

LOCATION OF EPICENTRES, 1922

Date	Station	O	Δ	Epicentre	Other Locations	Other Data
1362	No Location....				Zürich and	Hamburg 5200
Dec. 17					De Bilt give	Strasbourg (9580)
					Central Asia.	Algiers 6680
						Cartuja 9010
						Coimbra (8000)
						Lemberg 5800
						Königsberg (3960)
						Belgrade 1140
1363	Chicago........	12-35-01	3050	$\phi = 16°\cdot5$ N		
Dec. 18	Cheltenham.....	12-34-45	2500	$\lambda = 74°\cdot5$ W		
	Washington.....	12-35-55	2450	O = 12-35·0		
	Ithaca.........	12-34-56	2700			
1364	No Location....					No data.
Dec. 18						
1365	No Location....					No data.
Dec. 19						
1366	No Location....					Chicago (6920)
Dec. 23						La Paz 9400
						Perth 3750
1367	No Location....				Press reports	Coimbra 9400
Dec. 25					quake felt	La Paz (8200)
					in New Zealand.	Melbourne 2980
						Sydney 2150
						Perth 7500
1368	No Location....					No data.
Dec. 25						
1369	No Location....					No data.
Dec. 25						
1370	Dyce..........	7-20-19	8200	$\phi = 44°\cdot5$ N	Zürich gives	Chicago 3550
Dec. 31	Hamburg.......	7-20-03	8520	$\lambda = 149°\cdot5$ E	$\phi = 49°$ N	Victoria 2440
	Sitka.........	7-19-39	5070	O = 7-20-00	$\lambda = 143°$ E	Naples 7900
	Honolulu.......	7-19-54	5310			
	Coimbra........	7-20-41	9600		Uccle and Naples	
	Wien..........	7-20-09	8700		give Kurile	
	Athens........	7-20-07	9280		Is.	
	Osaka.........		1500			
	Königsberg......	(7-19-15)	(8940)			
	Stonyhurst......	7-20·0	8800			
	Manila.........	(7-19-02)	(5250)			
	Belgrade.......	7-20-20	8650			
	Innsbruck.......	7-20-22	8800			
	De Bilt........	7-20-03	8800			
	Uccle..........	7-20-11	8800			
	Zürich.........	7-20-09	8920			
	Ootomari.......		678			

DEPARTMENT OF THE INTERIOR
CANADA

HON. CHARLES STEWART, *Minister* W. W. CORY, C.M.G., *Deputy Minister*

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

R. MELDRUM STEWART, M.A., *Director*

Vol. VII

Seismology

No. 4

THE LOCATION OF EPICENTRES, 1923-4-5

BY

W. W. DOXSEE, M.A.

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1929

LOCATION OF EPICENTRES, 1923-1925

In continuation of the series of epicentre locations as determined at the Dominion Observatory, this issue carries the work forward through the three-year period beginning January 1, 1923, to the end of December, 1925, Greenwich mean dates. The results, in summary form, are as follows:—

Year	Total Number of Quakes recorded	Number for which Epicentres were determined
1923	308	83
1924	274	80
1925	369	107

Formerly an entry was made for every quake of which any trace was recorded at Ottawa, but with little or no sacrifice of the value of the results, the tabulation has been reduced to a list of earthquakes for which it was possible to locate the epicentre. This change accounts for the lack of continuity in the serial numbers which follow the dates in the first column.

The symbols employed are those of the standard notation:

Δ represents the arcual distance in kilometres from epicentre to station.

ϕ and λ the latitude and longitude, respectively, of the origin.

O the Greenwich mean time of the disturbance at its source.

The O values, as tabulated in the third column, may show considerable variation due to errors introduced by the person making the readings, table errors, and, not least, the clock error of the station. The most probable value for O, obtained from all available data, is given in the fifth column along with the determined geographical coördinates of the epicentre.

For the purpose of securing uniformity, this series, like those preceding, is based on the Klotz Tables, with the position of the epicentre determined by means of the stereographic projection method. This practice will be continued until other tables such as those of Macelwane or Gutenberg have been sufficiently tested in practice and adopted as standard.

Two unusually severe earthquakes occurred in the year 1923. The Tokyo earthquake of September 1 (No. 1573) was one of the greatest disasters of modern times causing great property damage and a heavy loss of life, this being due in part to the proximity of the epicentre to a thickly populated district. In point of severity, however, this quake ranks second to that which occurred on February 3 (No. 1387). The records show this latter disturbance to have been the most severe ever recorded at this station, with an actual earth displacement at Ottawa of 3·3 millimetres as compared to an earth movement of ·38 millimetres for the Tokyo quake. The origin of the February disturbance was in the North Pacific ocean far removed from inhabited sections. It is interesting to note that the tidal wave caused by this earth adjustment travelled over the Pacific at a rate of over 400 miles per hour and after 7 hours reached the shores of Hawaii with sufficient intensity to cause heavy damage to shipping and coast structures, and also the loss of several lives.

Other disturbances which are deserving of attention are Nos. 1477 and 1479 of May 30 and No. 1615 of October 10 in the year 1923, together with Nos. 1904 and 1905 of October 10, 1924, which show a continued siesmic activity in the regions north of the Arctic Circle.

During the year 1925, the North American continent experienced two earthquakes which are unique in that both occurred in regions which are subject to severe earthquakes only at comparatively rare intervals, and although both were of such intensity as to be recorded at all the principal seismic stations throughout the world, yet in neither instance was there direct loss of life. The disturbances referred to are the St. Lawrence earthquake of March 1 (No. 1999) and the Montana earthquake of June 28 (No. 2125).

DOMINION OBSERVATORY,
OTTAWA, CANADA,
April, 1928.

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Jan. 21	Wien	4-13-46	1240	ϕ = 36° N	
1378	Coimbra	4-13-16	2540	λ = 20°·5 E	
	Athens	4-13-26	330	O = 4-13-38	
	Belgrade	4-13-40	860		
	Innsbruck	4-13-53	1390		
	Uccle	4-13-46	1900		
Jan. 22	Honolulu	9-04-12	3800	ϕ = 41° N	Lick gives
1381	Sitka	9-03-59	2140	λ = 125° W	ϕ = 41° N
	Victoria	9-04-25	830	O = 9-04-10	λ = 124°·6 W.
	Berkeley	9-04-19	375		
	Lick	9-04-04	540		
	Tucson	9-04-18	1550		
	Denver	9-03-47	1750		
	Chicago	9-03-53	3150		
	Ottawa	9-04-10	3880		
	Georgetown	9-04-12	3960		
	Washington	9-03-47	3960		
	Wien	9-04-09	9680		
	Strasbourg	9-04-24	9080		
	Paris	9-04-08	9150		
	Algiers	9-04-23	9820		
	Cartuja	9-04-21	9580		
	Eskdalemuir	9-04-13	8160		
	Vieques	9-04-08	6240		
	Coimbra	9-03-58	9220		
	Toronto	9-04-15	4120		
	Fordham	9-04-12	4140		
	Cheltenham	9-04-04	4020		
	Northfield	9-03-57	4260		
	Ithaca	9-04-11	3850		
	Innsbruck	9-04-26	9280		
	Besançon	9-04-23	9150		
	Uccle	9-04-21	8800		
	Port au Prince	9-04-14	5560		
Feb. 1	Wien	19-32-14	9120	ϕ = 44° N	Cartuja gives
1384	Cartuja	19-32-03	10780	λ = 155° E	ϕ = 47° N
	Belgrade	19-31-54	9150	O = 19-32-08	λ = 176° W.
	Innsbruck	19-32-22	9150	Location approximate.	

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Feb. 2	Victoria	1-07-36	4480	ϕ = 55° N	
1385	Algiers	1-06-53	9560	λ = 166° E	
	Coimbra	1-07-11	9320	O = 1-06-39	
	Wien	1-06-42	8260		
	Helwan	1-06-40	9550		
	Cartuja	1-06-58	9700		
	Belgrade	1-06-04	8920		
	Chicago	1-06-20	7600		
	Osaka	1-06-13	3080		
	Innsbruck	1-06-42	8480		
	Kobe	1-06-47	2780		
	Königsberg	1-06-25	7780		
	Mizusawa	1-06-04	2330		
Feb. 2	Ottawa	5-08-21	7260	ϕ = 52° N	
1386	Fordham	(5-07-47)	8180	λ = 164° E	
	Toronto	5-08-48	7380	O = 5-07-45	
	Algiers	5-07-35	9740		
	Wien	5-08-02	7780		
	Coimbra	5-07-54	9420		
	Helwan	5-07-33	9650		
	Strasbourg	5-07-03	8920		
	Paris	5-07-28	8740		
	Cartuja	5-08-09	9420		
	Tucson	5-08-07	6920		
	Honolulu	5-08-05	4630		
	Berkeley	5-07-15	6160		
	Sitka	5-07-45	3680		
	Cheltenham	5-08-15	8180		
	Uccle	5-07-34	8350		
	Washington	5-07-45	8250		
	Chicago	5-07-35	7550		
	Belgrade	5-07-17	8700		
	Mizusawa	5-07-55	2030		
	Ithaca	5-07-49	7800		
	Batavia	5-08-01	8160		
	Barcelona	5-07-27	9400		
	Georgetown	5-07-30	8480		
	Athens	5-07-37	9020		
	Eskdalemuir	5-07-42	7950		
	Firenze	5-07-37	9000		
	Stonyhurst	5-07· 9	8080		
	Osaka	5-07-18	3100		
	Innsbruck	5-07-37	8540		
	Kobe	5-07-24	2930		
	Besançon	5-08-03	8520		
	Königsberg	5-07-38	7500		
	Moncalieri	5-07-54	8580		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Feb. 3	Ottawa	16-01-56	7620	ϕ = 52°·5 N	Apia gives
1387	Saskatoon		5750	λ = 162° E	ϕ = 47° N
	Fordham		7980	O = 16-01 40	λ = 172° W
	Algiers	16-01-51	9580		
	Toronto	16-02-30	7380		Uccle gives
	Coimbra	16-01-41	9820		ϕ = 50° N
	Lick		6110		λ = 167° E
	Wien	16-01-39	8350		
	Uccle	16-01-19	8670		Coimbra gives
	Strasbourg	16-01-12	9100		ϕ = 51°·4 N
	Berkeley	16-01-33	6020		λ = 161°·5 E
	Paris	16-01-03	9320		
	Moncalieri	16-01-32	9000		Sydney gives
	Cartuja	16-01-53	9700		ϕ = 52° N
	Tucson	16-01-41	7320		λ = 175° W.
	Cheltenham	16-02-02	8250		
	Sitka	16-01-42	3780		
	Honolulu	16-01-46	5020		
	Sydney	16-01-42	9800		
	Washington	16-01-46	8320		
	Chicago	16-01-22	7800		
	Barcelona	16-01-21	9820		
	Northfield	16-01-44	8050		
	Ithaca	16-01-49	7960		
	Melbourne	16-01-48	10180		
	Georgetown	16-01-43	8300		
	Firenze	16-01-16	9520		
	Innsbruck	16-01-43	8500		
	Lemberg	16-00· 9	7960		
	Zi-ka-wei	16-01-36	3880		
	Spring Hill	16-01-52	8440		
	Königsberg	16-01-35	7600		
Feb. 8	Ottawa	0-33-23	3660	ϕ = 18° N	
1398	Chicago	0-33-04	2930	λ = 98° W	
	Washington	0-33-38	2930	O = 0-33-23	
	La Paz	0-33-29	5050		
Feb. 11	Algiers	22-45-47	9500	ϕ = 54° N	
1405	Wien	22-45-36	8250	λ = 163° E	
	Chicago	22-45-38	7400	O = 22-45-37	
	Victoria	22-45-34	4880		
	Mizusawa	22-45-32	2430		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Feb. 12 1406	Algiers	1-58-58	9300	ϕ = 54° N	
	Wien	1-58-34	8280	λ = 165° E	
	Cartuja	1-58-59	9450	O = 1-58-49	
	Washington	1-59-02	8000		
	Chicago	1-58-56	7300		
	Mizusawa	1-58-37	2290		
	Belgrade	1-58-21	8640		
	Firenze	1-58-48	8700		
	Osaka	1-59-09	2550		
	Moncalieri	1-58-57	8500		
	Uccle	1-58-41	8150		
Feb. 16 1411	Algiers	9-16-18	9900	ϕ = 49° N	
	Strasbourg	9-15-33	9650	λ = 154° E	
	Zi-ka-wei	9-16-21	3180	O = 9-16-05	
	Ekaterinburg	9-15-53	6000		
	Uccle	9-16-21	8550		
Feb. 24 1417	Ottawa	7-34-48	7390	ϕ = 54° N	
	Halifax		7620	λ = 166°·7 E	
	Saskatoon		5400	O = 7-34-36	
	Fordham	7-34-28	8380		
	Algiers	7-34-22	9820		
	Coimbra	7-35-12	9000		
	Helwan	7-34-33	9520		
	Wien	7-34-24	8360		
	Strasbourg	7-34-34	8380		
	Cartuja	7-34-43	9780		
	Honolulu	7-34-36	4900		
	Sitka	7-34-32	3590		
	Cheltenham	7-35-01	7850		
	Belgrade	7-34-15	8850		
	Chicago	7-34-12	7480		
	Barcelona	7-34-43	9160		
	Georgetown	7-34-50	8020		
	Victoria	7-34-44	4700		
	Athens	7-34-55	8840		
	Moncalieri	7-34-53	8540		
	Lick		5950		
	Berkeley	7-34-19	5950		
	Eskdalemuir	7-34-47	7650		
	Stonyhurst	7-34·7	7960		
	Osaka	7-34-15	3190		
	Innsbruck	7-34-18	8650		
	Besançon	7-34-40	8580		
	Königsberg	7-34-31	7500		
	Uccle	7-34-39	8200		
	Tyosi	7-34-27	2720		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Mar. 1	Ottawa.............	8–26–15	6240	ϕ = 49° N	
1422	Zi-ka-wei...........	8–26–37	5850	λ = 171° W	
	Ekaterinburg........	8–26–08	7350	O = 8–26–20	
Mar. 15	Ottawa.............	5–40–16	7020	ϕ = 43° N	Cartuja gives
1433	Paris..............	5–39–49	1160	λ = 17°·2 E	ϕ = 43° 48′ N
	Strasbourg..........	5–40–36	830	O = 5–40–21	λ = 17° 28′ E.
	Algiers............	5–39–51	1620		
	Cartuja............	5–40–28	1920		Belgrade gives
	Belgrade...........	5–40–01	420		ϕ = 43° 25′ 30″ N
	Eskdalemuir........	5–40–08	2030		λ = 17° 16′ 50″ E.
	Chicago............	5–40–27	7920		
	Wien...............	5–40–23	520		De Bilt gives
	Innsbruck..........	5–40–15	700		ϕ = 43° 20′ N
	Athens.............	5–40–30	680		λ = 17° 10′ E.
	Helwan.............	5–40–30	1840		
	De Bilt............	5–40–24	1310		
	Besançon...........	5–40–40	870		
	Lemberg............	5–40·0	1060		
	Ekaterinburg........	5–41–10	2860		
	Moncalieri..........	5–40–35	720		
	Uccle..............	5–40–22	1260		
Mar. 24	Cartuja............	12–39–41	9740	ϕ = 30°·5 N	
1441	Strasbourg..........	12–40–04	7800	λ = 101°·5 E	
	Victoria...........	12–40–51	9440	O = 12–40–10	
	Osaka..............	12–40–12	3190		
	Eskdalemuir........	12–40–05	8080		
	Stonyhurst..........	12–39·4	9150		
	Taihoku............	12–40–17	2230		
	Wien...............	12–40–06	7180		
	Innsbruck..........	12–40·3	7480		
	Helwan.............	12–40–07	6600		
	Kobe...............	12–40–03	3160		
	De Bilt............	12–40–17	7680		
	Barcelona...........	12–40–30	8360		
	Batavia............	12–40–00	4120		
	Ekaterinburg........	12–40–32	3850		
	Mizusawa...........	12–40–15	3520		
	Tyosi..............	12–40–05	3690		
	Uccle..............	12–40–11	7860		
	Moncalieri..........	12–40–12	7960		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
April 13 1446	Ottawa	15-31-12	7380	ϕ = 56° N	
	Victoria	15-30-58	4780	λ = 163° E	
	Paris	15-30-50	8380	O = 15-30-56	
	Strasbourg	15-30-55	8250		
	Sitka	15-30-49	4600		
	Honolulu	15-31-01	5020		
	Belgrade	15-31-07	8280		
	Wien	15-31-00	8100		
	Algiers	15-31-09	9340		
	Chicago	15-30-25	7700		
	Hamburg	15-31-00	7650		
	Athens	15-31-06	8820		
	Uccle	15-31-05	7950		
	Berkeley	15-30-52	5700		
	De Bilt	15-30-56	7950		
	Mizusawa	15-30-44	2500		
	Wellington	15-31-16	10550		
	Tyosi	15-30-31	2900		
April 19 1450	Melbourne	3-09·1	5660	ϕ = 7° N	
	Wien	3-09-53	9550	λ = 117° E	
	Helwan	3-09-20	9220	O = 3-09-10	
	Zi-ka-wei	3-09-40	2660	Location and O	
	Batavia	3-08-36	1750	approximate.	
	Malabar	3-08-41	1780		
	Ekaterinburg	3-08-50	8020		
April 23 1451	Victoria	3-17-09	9050	ϕ = 29° N	
	Wien	3-16-40	9380	λ = 126° E	
	Ootomari	3-17-03	2450	O = 3-16-58	
	Uccle	3-17-14	9230	Location approximate.	
	De Bilt	3-17-15	9250		
	Ekaterinburg	3-16-49	5990		
	Eskdalemuir	3-17-10	9340		
	Mizusawa	3-16-42	2020		
	Tyosi	3-16-41	1810		
April 29 1456	Algiers	9-33-59	3240	ϕ = 43° N	
	Athens	9-33-49	1510	λ = 40° E.	
	Uccle	9-34-24	2780	O = 9-34-09	
	De Bilt	9-34-24	2780	Location and O approximate.	

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
May 4	Ottawa............	16-26-34	5520	ϕ = 55°·0 N	Uccle gives
1462	Harvard...........	16-26-31	6040	λ = 156°·5 W	ϕ = 54° N
	Dyce..............	16-26-43	7320	O = 16-26-42	λ = 154° W.
	Strasbourg..........	16-26-20	8400		
	Wien..............	16-26-40	8550		
	Algiers.............	16-26-45	9520		
	Ekaterinburg........	16-26-41	7120		
	Georgetown.........	16-26-36	5920		
	Ithaca.............	16-26-31	5700		
	Firenze.............	16-26-52	8900		
	Sitka..............	16-26-46	1210		
	Eskdalemuir........	16-26-40	7560		
	Tucson.............	16-26-47	4210		
	Chicago............	16-26-55	4750		
	Northfield..........	16-26-28	5780		
	Cartuja............	16-26-45	9410		
	Honolulu...........	16-26-40	3660		
	Besançon...........	16-26-42	8620		
	Hamburg...........	16-26-42	7900		
	Mizusawa..........	16-26-37	4740		
	Agram.............	16-26-48	8700		
	Athens............	16-26-50	9350		
	Coimbra...........	16-27-04	8720		
	Helwan............	16-26-55	10260		
	Manila............	16-26-54	8080		
	Barcelona.........	16-26-53	9000		
	Paris..............	16-26-47	8280		
	Zi-ka-wei..........	16-26-38	6640		
	Spring Hill.........	16-26-32	5500		
	Moncalieri..........	16-26-44	8800		
	De Bilt............	16-26-41	8060		
	Uccle.............	16-26-41	8160		
	Innsbruck..........	16-26-35	8700		
	Belgrade...........	16-26-28	9000		
May 12	Helwan............	1-19-56	9080	ϕ = 3° S	Ekaterinburg gives
1469	Sydney............	1-19-34	5750	λ = 110° E	ϕ = 0° 18′ S
	Belgrade...........	1-19-55	10150	O = 1-19-40	λ = 115° 43′ E.
	Ekaterinburg........	1-19-16	8000	Location approximate.	

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
May 23 1472	Ottawa	22-37-21	7580	ϕ = 52°·0 N	Ekaterinburg gives
	Strasbourg	22-36-50	8820	λ = 163°·7 E	ϕ = 66° 23′ N
	Washington	22-37-05	8360	O = 22-37-03	λ = 156° 55′ W.
	Victoria	22-36-47	5050		
	Honolulu	22-37-26	4630		
	Toronto	22-37-35	7460		
	Hamburg	22-36-57	8120		
	Osaka	22-37-12	3100		
	Zi-ka-wei	22-37-02	3880		
	Tyosi	22-36-52	2590		
	Moncalieri	22-36-50	9120		
	De Bilt	22-37-04	8220		
	Uccle	22-37-06	8320		
	Belgrade	22-36-41	8740		
	Cartuja	22-37-23	9700		
	Ekaterinburg	22-36-52	5950		
	Wien	22-37-07	8380		
	Agram	22-37-02	8700		
	Eskdalemuir	22-36-53	8120		
	Coimbra	22-37-13	9400		
	Mizusawa	22-36-54	2370		
May 28 1476	Algiers	1-26-01	9600	ϕ = 2° S	Ekaterinburg gives
	Strasbourg	1-26-00	9410	λ = 88°·5 E	ϕ = 3° 4′ S
	Athens	1-25-57	7950	O = 1-26-00	λ = 86° 25′ E.
	Osaka	1-26-30	6180		
	Paris	1-26-15	9450		
	Zi-ka-wei	1-25-38	5120		
	De Bilt	1-26-05	9510		
	Uccle	1-26-06	9480		
	Ekaterinburg	1-25-49	7080		
	Batavia	1-26-04	2000		
	Wien	1-25-53	8900		
	Agram	1-26	8800		
	Eskdalemuir	1-26-16	9750		
	Moncalieri	1-25-40	9650		
May 30 1477	Algiers	8-30-32	6900	ϕ = 77° N	
	Strasbourg	8-30-39	5400	λ = 128° E	
	Victoria	8-30-30	5280	O = 8-30-36	
	Hamburg	8-30-34	4850		
	Paris	8-30-34	5500		
	Zi-ka-wei	8-30-37	5120		
	De Bilt	8-30-35	5080		
	Uccle	8-30-33	5240		
	Innsbruck	8-30-49	5300		
	Wien	8-30-36	5280		
	Agram	8-30-33	5650		
	Coimbra	8-30-38	6700		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
May 30	Algiers	17–57–00	6750	ϕ = 77° N	
1479	Strasbourg	17–56–40	5500	λ = 125° E	
	Victoria	17–57–12	5120	O = 17–56–57	
	Hamburg	17–56–45	4850		
	Paris	17–56–52	5450		
	Zi-ka-wei	17–57–04	4900		
	Moncalieri	17–56–41	5870		
	De Bilt	17–56–48	5080		
	Uccle	17–56–47	5240		
	Belgrade	17–57–24	5200		
	Wien	17–57–15	4880		
	Agram	17–56–53	5530		
	Eskdalemuir	17–56–57	4740		
	Coimbra	17–56–55	6640		
May 31	Ottawa	22–05–48	3380	ϕ = 31°·3 N	
1481	Algiers	22–05–49	4060	λ = 41° W	
	Strasbourg	22–05–50	4500	O = 22–05–53	
	Toronto	22–05–47	3620		
	Hamburg	22–05–51	4750		
	La Paz	22–06–02	6110		
	Moncalieri	22–05–47	4500		
	De Bilt	22–05–52	4370		
	Uccle	22–05–57	4210		
	Coimbra	22–06–03	3020		
June 1	Ottawa	17–25–31	9320	ϕ = 37° N	Strasbourg gives
1482	Strasbourg	17–24–55	9420	λ = 140° E	ϕ = 38° N
	Sitka	17–23–47	6860	O = 17–24–52	λ = 139° E.
	Honolulu	17–24–31	6100		
	Chicago	17–25–22	9300		
	Algiers	17–25–11	10050		
	Victoria	17–24–55	7400		
	Hamburg	17–24–48	9020		
	Helwan	17–25–03	9320		
	Paris	17–24–58	9560		
	Zi-ka-wei	17–24–36	1970		
	Athens	17–25–12	9150		
	Innsbruck	17–25–03	9300		
	Uccle	17–24–50	9400		
	Wien	17–24–51	9100		
	Batavia	17–24–41	5810		
	Firenze	17–24–53	9580		
	Sydney	17–24–50	7760		
	Agram	17–24–47	9340		
	Cartuja	17–24–59	10850		
	Eskdalemuir	17–24–46	9340		
	Stonyhurst	17–25·1	9280		
	Belgrade	17–24–45	9150		
	De Bilt	17–24–49	9310		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
June 1 1483	Strasbourg..........	20–15–55	9400	ϕ = 37° N	Strasbourg gives
	Chicago..........	20–16–38	9120	λ = 142° E	ϕ = 38° N
	Victoria..........	20–15–58	7460	O = 20–15–53	λ = 139° E.
	Algiers..........	20–16–11	10150		
	Hamburg..........	20–15–49	9010		
	Paris..........	20–16–08	9480		
	Zi-ka-wei..........	20–15–33	2000		
	Athens..........	20–15–56	9300		
	Uccle..........	20–15–50	9400		
	Wien..........	20–15–52	9100		
	Firenze..........	20–15–29	9480		
	Sydney..........	20–15–47	7780		
	Agram..........	20–15–56	9250		
	Eskdalemuir..........	20–15–47	9320		
	Ekaterinburg..........	20–15–46	6110		
	Belgrade..........	20–15–42	9200		
	Innsbruck..........	20–15–51	9420		
	De Bilt..........	20–15–49	9310		
June 18 1501	Tucson..........	8–16–14	8550	ϕ = 13° S	
	Sitka..........	8–16–28	8620	λ = 177° W	
	Honolulu..........	8–16–30	4210	O = 8–16–16	
	Wellington..........	8–15–54	2620	Location approximate.	
June 19 1504	Ottawa..........	22–43–32	4900	ϕ = 61°·8 N	
	Georgetown..........	22–43–36	5450	λ = 152°·5 W	
	Cheltenham..........	22–43–27	5580	O = 22–43–34	
	Sitka..........	22–43–52	1090		
	Washington..........	22–43–35	5450		
	Toronto..........	22–43–35	4820		
	Eskdalemuir..........	22–43–31	6730		
	Ekaterinburg..........	22–43–38	6470		
	Pulkovo..........	22–43–23	6640		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
June 22 1507	Strasbourg	6-44-38	8200	ϕ = 23° N	
	Algiers	6-44-31	8980	λ = 99°·5 E	
	Hamburg	6-44-37	8000	O = 6-44-39	
	Helwan	6-44-33	6680		
	De Bilt	6-44-39	8300		
	Barcelona	6-44-38	8880		
	Paris	6-44-36	8640		
	Zi-ka-wei	6-44-40	2350		
	Athens	6-44-34	7220		
	Coimbra	6-44-47	9440		
	Moncalieri	6-44-48	8180		
	Stonyhurst	6-45·0	8550		
	Wien	6-44-35	7650		
	Belgrade	6-44-45	7240		
	Uccle	6-44-36	8440		
	Innsbruck	6-44-56	7700		
	Sydney	6-44-40	8360		
	Agram	6-44-42	7620		
	Lemberg	6-44·4	7250		
	Cartuja	6-44-42	9450		
	Taihoku	6-44-17	2420		
	Mizusawa	6-44-36	4240		
July 2 1517	Strasbourg	2-31-51	9750	ϕ = 22° N	
	Victoria	2-32-19	9580	λ = 119° E	
	Paris	2-32-29	9350	O = 2-31-57	
	Zi-ka-wei	2-31-08	1120		
	Osaka	2-31-49	2030		
	Kobe	2-31-22	2080		
	Agram	2-32-07	9160		
	Pulkovo	2-32-12	7650		
	Hamburg	2-31-50	9440		
	De Bilt	2-32-10	9340		
	Wien	2-31-56	9220		
	Moncalieri	2-32-14	9620		
July 10 1527	Victoria	0-29-36	9660	ϕ = 30° S	
	Toronto	0-29-16	8100	λ = 75° W	
	Georgetown	0-29-12	7680	O = 0-29-10	
	La Paz	0-28-52	1710	Location approximate.	
	Rio de Janeiro	0-28-53	3030		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
July 10 1528	Strasbourg	5-31-18	900	ϕ = 43° N	
	Algiers	5-30-52	900	λ = 2° W	
	Barcelona	5-31-15	280	O = 5-31-12	
	Paris	5-31-17	700		
	Uccle	5-31-23	890		
	Agram	5-31-05	1460		
	Pulkovo	5-30-39	3050		
	Hamburg	5-31-00	1600		
	De Bilt	5-31-20	1070		
	Innsbruck	5-31-28	1000		
	Besançon	5-31-08	800		
	Coimbra	5-31-31	560		
	Wien	5-31-22	1400		
	Cartuja	5-31-17	620		
July 13 1531	Strasbourg	11-13-52	9280	ϕ = 31°·3 N	Ekaterinburg gives
	Honolulu	11-13-47	7000	λ = 131°·0 E	ϕ = 26° 53′ N
	Sitka	11-13-38	7250	O = 11-13-43	λ = 124° 19′ E.
	Victoria	11-13-23	8700		
	Helwan	11-13-40	9150		Uccle gives
	Paris	11-14-00	9340		ϕ = 37° N
	Zi-ka-wei	11-13-43	850		λ = 140° E.
	Ekaterinburg	11-13-40	5950		
	Wien	11-13-27	9350		
	Cartuja	11-13-38	11150		
	Kobe	11-13-22	670		
	Uccle	11-13-45	9340		
	Firenze	11-13-47	9600		
	Agram	11-13-41	9230		
	Sydney	11-13-51	7270		
	Eskdalemuir	11-13-49	9280		
	Manila	11-14-20	1690		
	Pulkovo	11-13-31	7770		
	Hamburg	11-13-21	9450		
	De Bilt	11-13-42	9300		
	Innsbruck	11-13-44	9340		
	Belgrade	11-13-55	8750		
	Stonyhurst	11-13·8	9400		
July 14 1533	Victoria	23-56-16	8600	ϕ = 29°·4 N	Ekaterinburg gives
	Zi-ka-wei	23-56-14	920	λ = 131°·5 E	ϕ = 30° N
	Pulkovo	23-56-07	7770	O = 23-56-14	λ = 128° 28′ E.
	De Bilt	23-56-24	9230		
	Wien	23-56-02	9380		
	Ekaterinburg	23-56-22	5930		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
July 16 1534	Honolulu...........	13-38-18	5550	ϕ = 13° S	
	Victoria............	13-38-37	9600	λ = 169° E	
	Sydney.............	13-38-04	2840	O = 13-38-20	
				Location approximate.	
July 17 1535	Victoria............	1-01-52	2320	ϕ = 61° N	
	Pulkovo............	1-02-12	6190	λ = 155° W	
	Cartuja.............	1-01-55	8820	O = 1-02-02	
	Ekaterinburg........	1-02-11	6540		
July 18 1536	Ottawa.............	1-05-55	3600	ϕ = 43°·6 N	
	Strasbourg..........	1-05-50	2920	λ = 29°·5 W	
	Toronto............	1-05-46	4020	O = 1-05-55	
	Algiers.............	1-05-46	2890		
	Barcelona...........	1-05-54	2610		
	Paris...............	1-05-57	2520		
	Uccle...............	1-05-53	2640		
	Agram..............	1-05-52	3470		
	Pulkovo............	1-05-51	4260		
	De Bilt.............	1-05-52	2720		
	Coimbra............	1-06-18	1600		
	Cartuja.............	1-05-53	2340		
	Ekaterinburg........	1-06-09	6120		
July 18 1537	Ottawa.............	6-02-13	3580	ϕ = 43°·6 N	
	Strasbourg..........	6-02-15	2800	λ = 29°·5 W	
	Chicago............	6-02-14	4600	O = 6-02-11	
	Toronto............	6-02-05	3980		
	Algiers.............	6-01-57	2920		
	Barcelona...........	6-02-15	2590		
	Paris...............	6-02-14	2510		
	Uccle...............	6-02-10	2640		
	Agram..............	6-01-56	3650		
	Pulkovo............	6-02-08	4280		
	Hamburg...........	6-02-07	3040		
	De Bilt.............	6-02-09	2720		
	Coimbra............	6-02-41	1550		
	Cartuja.............	6-02-12	2330		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
July 20 1539	Strasbourg..........	15-02-29	6000	ϕ = 0°·5 S	
	Washington.........	15-02-49	7800	λ = 13°·5 W	
	Algiers............	15-02-34	4450	O = 15-02-38	
	Helwan.............	15-02-44	5820		
	Paris..............	15-02-44	5680		
	Athens.............	15-02-38	5740		
	La Paz.............	15-02-33	6240		
	Uccle..............	15-02-35	6000		
	Agram..............	15-02-39	5920		
	Pulkovo............	15-02-49	7650		
	Hamburg............	15-02-41	6390		
	De Bilt............	15-02-37	6180		
	Barcelona..........	15-02-32	4950		
	Innsbruck..........	15-02-16	6080		
	Coimbra............	15-02-35	4520		
	Wien...............	15-02-38	6240		
	Cartuja............	15-02-34	4320		
	Ekaterinburg........	15-03-06	9030		
	Moncalieri..........	15-02-37	5520		
July 22 1541	Ottawa.............	14-18-07	7320	ϕ = 52°·0 N	
	Strasbourg..........	14-18-14	8640	λ = 171°·6 E	
	Cheltenham.........	14-17-25	7880	O = 14-18-12	
	Honolulu...........	14-17-41	4260		
	Sitka..............	14-18-45	2880		
	Washington.........	14-18-08	7860		
	Chicago............	14-18-18	6800		
	Victoria...........	14-17-59	4220		
	Toronto............	14-17-46	7350		
	Coimbra............	14-18-36	9060		
	Algiers............	14-18-31	9450		
	Helwan.............	14-18-38	9420		
	Ithaca.............	14-18-00	7600		
	Paris..............	14-18-10	8720		
	Zi-ka-wei...........	14-18-46	3950		
	Georgetown.........	14-18-14	7800		
	Moncalieri..........	14-18-04	9200		
	Wien...............	14-18-09	8600		
	Ekaterinburg........	14-18-15	6490		
	Kobe...............	14-18-34	3180		
	Uccle..............	14-18-05	8540		
	Agram..............	14-18-06	8900		
	Cartuja............	14-18-22	9860		
	Berkeley...........	14-18-47	4720		
	Pulkovo............	14-17-52	7300		
	Hamburg...........	14-18-06	8150		
	De Bilt............	14-18-03	8440		
	Barcelona...........	14-18-28	9230		
	Belgrade............	14-17-50	9200		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
July 23 1542	Tucson	7-30-42	610	ϕ = 35° N	
	Chicago	7-30-20	2650	λ = 117° W	
	Ekaterinburg	7-31-14	9350	O = 7-30-45	
				Location approximate.	
July 31 1547	Honolulu	15-07-49	4120	ϕ = 52°·5 N	
	Chicago	15-08-08	6900	λ = 174°·5 E	
	Victoria	15-07-55	4300	O = 15-07-56	
	Agram	15-08-10	8800		
	Pulkovo	15-08-10	7050		
	Ekaterinburg	15-07-26	6460		
Aug. 1 1549	Strasbourg	8-16-31	2050	ϕ = 35°·7 N	Pulkovo gives
	Algiers	8-16-30	1980	λ = 26°·5 E	ϕ = 36°·2 N
	Helwan	8-16-36	720	O = 8-16-31	λ = 26°·1 E
	Paris	8-16-40	2300		
	Athens	8-16-42	315		Ekaterinburg gives
	Uccle	8-16-32	2360		ϕ = 35° 53′ N
	Besançon	8-16-36	2030		λ = 27° 17′ E.
	Innsbruck	8-16-49	1610		
	Eskdalemuir	8-16-29	2950		
	Barcelona	8-16-32	2080		
	De Bilt	8-16-25	2460		
	Coimbra	8-16-34	2820		
	Hamburg	8-16-26	2360		
	Cartuja	8-16-31	2500		
	Pulkovo	8-16-31	2640		
	Ekaterinburg	8-15-59	3400		
Aug. 8 1554	Strasbourg	12-01-35	7550	ϕ = 12°·8 N	
	Victoria	12-01-31	6760	λ = 63°·5 W	
	Ithaca	12-01-57	3140	O = 12-01-28	
	Georgetown	12-01-31	3170		
	Chicago	12-01-25	3950		
	Toronto	12-01-26	3680		
	Uccle	12-01-29	7380		
	De Bilt	12-01-28	7480		
	Coimbrra	12-00-40	6500		
	Pulkovo	12-01-35	8940		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 8 1555	Strasbourg.......... Algiers.............. Paris................ Uccle............... Wien............... Barcelona........... De Bilt............. Coimbra............ Cartuja............. Pulkovo............ Ekaterinburg........	12–17–32 12–17–29 12–17–26 12–17–26 12–17–21 12–17–18 12–17–13 12–17–20 12–17–27 12–17–28 12–17–24	6400 5000 6180 6400 7020 5550 6780 4880 4690 8450 9820	ϕ = 3° S λ = 22° W O = 12–17–24 Location approximate.	
Aug. 10 1556	De Bilt............. Pulkovo............ Ekaterinburg........	2–17–21 2–17–24 2–17–10	5420 3780 2340	ϕ = 38° N λ = 74° E O = 2–17–18 Location approximate.	Ekaterinburg gives ϕ = 38° 26′ N λ = 76° 34′ E
Aug. 10 1557	Strasbourg.......... Algiers.............. Uccle............... Wien............... De Bilt............. Pulkovo............ Ekaterinburg........	15–57–54 15–58–22 15–58–15 15–58–16 15–58–17 15–58–05 15–57–58	8250 8450 8000 7180 7900 6390 4450	ϕ = 21° N λ = 91° E O = 15–58–10	Ekaterinburg gives ϕ = 23° 36′ N λ = 91° 23′ E.
Aug. 12 1561	Strasbourg.......... Victoria............ Uccle............... Zi-ka-wei........... Mizusawa........... Wien............... Belgrade............ De Bilt............. Hamburg........... Pulkovo............	10–06–28 10–06–12 10–06–33 10–06–19 10–06–12 10–06–02 10–05–58 10–06–25 10–06–22 10–06–07	9400 9120 9370 900 1930 9440 9600 9400 9230 8070	ϕ = 25° N λ = 129° E O = 10–06–16	
Aug. 16 1563	Mizusawa........... De Bilt............. Pulkovo............ Ekaterinburg........	20–22–49 20–22–37 20–21–32 20–22–26	970 8700 7180 5890	ϕ = 45° N λ = 151° E O = 20–22–20 Location approximate.	Ekaterinburg gives ϕ = 46° 28′ N λ = 152° 25′ E.

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 17	Victoria	1-05-20	9440	ϕ = 24° S	
1564	Algiers	1-04-48	10560	λ = 72° W	
	Rio de Janeiro	1-04-50	2820	O = 1-05-07	
	La Paz	1-05-23	900		
	Coimbra	1-05-14	9500		
Aug. 28	Ottawa	23-15-17	3470	ϕ = 24°·4 N	
1571	Sitka	23-14-25	4350	λ = 106°·0 W	
	Tucson	23-14-33	1120	O = 23-15-06	
	Honolulu	23-14-24	5120		
	Victoria	23-14-30	3120		
	Ithaca	23-15-23	3230		
	Paris	23-15-22	9300		
	Toronto	23-15-20	3140		
	Chicago	23-15-17	2600		
	Rio de Janeiro	23-15-21	8800		
	La Paz	23-14-58	6540		
	Uccle	23-15-26	9210		
	De Bilt	23-15-25	9220		
	Hamburg	23-15-48	8950		
Sept. 1	Ottawa	2-58-59	9760	ϕ = 35°·1 N	Uccle gives
1573	Saskatoon	2-58-35	8520	λ = 140°·2 E	ϕ = 36° N
	Halifax	2-58-55	10050	O = 2-58-36	λ = 142° E.
	Helwan	2-58-43	9340		
	Berkeley	2-58-29	8480		Pulkovo gives
	Lick	2-58-23	8720		ϕ = 34° 9′ N
	Paris	2-58-42	9560		λ = 139° 6′ E.
	Tucson	2-58-40	9580		
	Honolulu	2-58-30	6280		Ekaterinburg gives
	Cheltenham	2-58-36	10750		ϕ = 35° 17′ N
	Sitka	2-57-58	6980		λ = 138° 57′ E.
	Ithaca	2-59-12	9700		
	Chicago	2-59-05	9480		
	Northfield	2-59-18	9660		
	Toronto	2-58-37	10180		
	Victoria	2-58-24	7900		
	Georgetown	2-58-00	10650		
	Taihoku	2-58-29	2090		
	Osaka	2-58-42	380		
	Perth	2-58-54	7620		
	Sydney	2-58-43	7680		
	Wellington	2-58-57	8920		
	Jinsen	2-58-01	1090		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Sept. 1	Lemberg...........	2-58-32	8780		
1573	Strasbourg..........	2-58-36	9470		
	Agram.............	2-58-37	9280		
	München...........	2-58-28	9500		
	Zi-ka-wei...........	2-58-29	1770		
	Uccle.............	2-58-33	9470		
	Batavia............	2-58-21	5750		
	La Paz............	2-58-32	16500		
	Innsbruck..........	2-58-54	9150		
	Wien..............	2-58-21	9400		
	De Bilt............	2-58-32	9340		
	Belgrade...........	2-58-30	9340		
	Hamburg...........	2-58-20	9280		
	Cartuja............	2-58-30	11300		
	Pulkovo...........	2-58-32	7670		
	Ekaterinburg........	2-58-28	6110		
Sept. 2	Ottawa............	2-47-11	9560	ϕ = 35°·2 N	Uccle gives
1574	Helwan............	2-46-57	9300	λ = 139°·8 E	ϕ = 38° N
	Sitka.............	2-46-37	6550	O = 2-46-48	λ = 142° E.
	Tucson............	2-46-23	9675		
	Honolulu..........	2-46-45	6080		
	Paris.............	2-47-01	9380		
	Victoria...........	2-46-39	7700		Ekaterinburg gives
	Osaka.............	2-47-08	415		ϕ = 34° 9′ N
	Berkeley...........	2-46-40	8260		λ = 137° 38′ E.
	Jinsen............	2-46-39	1320		
	Wien..............	2-46-42	9230		
	Strasbourg..........	2-46-59	9280		
	Uccle.............	2-46-51	9330		
	Batavia............	2-46-57	5450		
	Sydney............	2-46-34	7780		
	Manila............	2-46-03	3060		
	Lemberg...........	2-46-45	8680		
	Wellington..........	2-47-03	8920		
	Zi-ka-wei...........	2-46-55	1690		
	Innsbruck..........	2-47-07	9160		
	Eskdalemuir........	2-46-52	9200		
	De Bilt............	2-46-47	9300		
	Sarajevo...........	2-46-51	9300		
	Hamburg...........	2-46-42	9090		
	Cartuja............	2-47-00	11220		
	Pulkovo...........	2-46-44	7670		
	Ekaterinburg........	2-46-38	6130		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Sept. 2	Helwan............	9-27-16	9220	ϕ = 35°·5 N	Pulkovo gives
1575	Paris..............	9-27-18	9300	λ = 140° E	ϕ = 35°·8 N
	Honolulu..........	9-26-53	6110	O = 9-27-02	λ = 141°·7 E.
	Chicago............	9-27-21	9480		
	Victoria............	9-26-56	7600		Ekaterinburg gives
	Jinsen..............	9-27-02	1300		ϕ = 35° 40′ N
	Strasbourg.........	9-27-07	9300		λ = 139° 29′ E.
	Batavia............	9-26-52	5660		
	Uccle..............	9-27-05	9280		
	Zi-ka-wei..........	9-26-51	1830		
	Innsbruck..........	9-27-26	9050		
	Eskdalemuir........	9-27-04	9160		
	De Bilt............	9-27-01	9250		
	Hamburg...........	9-26-57	9020		
	Pulkovo............	9-26-55	7690		
	Ekaterinburg.......	9-26-33	6300		
Sept. 2	Strasbourg.........	13-09-25	9340	ϕ = 37° N	Ekaterinburg gives
1576	Mizusawa..........	13-09-07	520	λ = 142° E	ϕ = 36° 9′ N
	Wien...............	13-09-18	9050	O = 13-09-16	λ = 138° 57′ E
	De Bilt............	13-09-19	9250	Location approximate.	
	Pulkovo............	13-09-18	7560		
	Ekaterinburg.......	13-09-09	6040		
Sept. 2	Strasbourg............	14-16-23	9450	ϕ = 36°·0 N	Ekaterinburg gives
1577	Zi-ka-wei..........	14-16-21	1810	λ = 141°·0 E	ϕ = 34° 23′ N
	Mizusawa..........	14-16-32	470	O = 14-16-25	λ = 137° 58′ E.
	Pulkovo............	14-16-32	7600		
	Ekaterinburg.......	14-16-17	6160		
Sept. 2	Paris..............	22-38-28	9220	ϕ = 13° S	
1578	Washington.........	22-38-03	5960	λ = 66° W	
	Toronto............	22-38-08	6480	O = 22-38-30	
	Victoria............	22-38-14	8700	Location approximate.	
	Algiers............	22-38-23	9000		
	Rio de Janeiro.......	22-38-08	2500		
	Strasbourg.........	22-38-47	9230		
	Uccle..............	22-38-40	9230		
	Besançon..........	22-38-44	9150		
	Innsbruck..........	22-38-54	9300		
	Eskdalemuir........	22-38-34	9150		
	De Bilt............	22-38-46	9230		
	Hamburg...........	22-38-54	9340		
	Cartuja............	22-38-21	8740		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Sept. 9	Helwan............	22-03-45	5740	ϕ = 24°·2 N	Pulkovo gives
1581	Paris.............	22-03-53	7800	λ = 90°·0 E	ϕ = 24°·4 N
	Algiers............	22-03-54	8150	O = 22-03-50	λ = 89°·1 E.
	Osaka.............	22-03-52	4220		
	Athens............	22-03-46	6350		
	Strasbourg..........	22-03-49	7430		
	Uccle..............	22-03-46	7690		
	Lemberg............	22-04-20	5900		
	Zi-ka-wei...........	22-03-32	2990		
	Eskdalemuir........	22-03-57	7900		
	Barcelona...........	22-03-55	8060		
	De Bilt............	22-03-49	7580		
	Belgrade...........	22-03-50	6540		
	Hamburg...........	22-03-47	7240		
	Cartuja............	22-03-48	8920		
	Pulkovo............	22-03-42	5950		
Sept. 11	Strasbourg..........	9-07-55	2660	ϕ = 45° N	
1584	Uccle..............	9-07-53	2430	λ = 28° W	
	De Bilt............	9-07-39	2560	O = 9-07-36	
	Ekaterinburg........	9-06-57	5780	Location approximate.	
Sept. 17	Helwan............	7-08-53	2700	ϕ = 38° N	
1589	Athens............	7-08-49	3030	λ = 59° E	
	Strasbourg..........	7-09-41	3600	O = 7-09-06	
	Uccle..............	7-09·1	4340		
	Innsbruck...........	7-09-00	3950		
	Wien..............	7-09-08	3420		
	Belgrade...........	7-09-02	3250		
	Hamburg...........	7-09-10	3920		
	Pulkovo...........	7-09-07	3100		
Sept. 22	Helwan............	20-47-37	2450	ϕ = 30° N	Pulkovo gives
1598	Paris.............	20-47-38	4950	λ = 56°·5 E	ϕ = 30° 19′ N
	Algiers............	20-47-41	4850	O = 20-47-37	λ = 55° 37′ E.
	Athens............	20-47-08	3420		
	Strasbourg..........	20-47-52	4350		Ekaterinburg gives
	Uccle..............	20-47-33	4870		ϕ = 29° 41′ N
	Lemberg............	20-47-51	3250		λ = 54° 25′ E.
	Zi-ka-wei...........	20-47-40	6110		
	Mizusawa..........	20-47-56	7390		
	Innsbruck...........	20-47-31	4320		
	Wien..............	20-47-20	4040		
	Barcelona...........	20-47-52	4800		
	De Bilt............	20-47-41	4820		
	Belgrade...........	20-47-38	3500		
	Hamburg...........	20-47-17	4780		
	Cartuja............	20-47-46	5500		
	Pulkovo............	20-47-36	3780		
	Ekaterinburg........	20-47-30	3050		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Sept. 26	Algiers	2-29-01	5250	ϕ = 1°·8 N	
1603	Rio de Janeiro	2-29-55	2620	λ = 33° W	
	Strasbourg	2-29-17	6450	O = 2-29-15	
	La Paz	2-29-34	4370		
	Cartuja	2-28-29	5450		
	Pulkovo	2-29-19	8350		
	Ekaterinburg	2-29-13	10070		
Sept. 26	Paris	8-24-10	9350	ϕ = 34° N	Ekaterinburg gives
1604	Victoria	8-23-40	7850	λ = 138° E	ϕ = 42° 19′ N
	Strasbourg	8-23-50	9560	O = 8-23-50	λ = 149° 19′ E.
	Zi-ka-wei	8-23-52	1630		
	Mizusawa	8-23-11	780		
	Innsbruck	8-24·0	9400		
	Wien	8-23-43	9300		
	Belgrade	8-24-03	9000		
	Hamburg	8-23-56	9000		
	Pulkovo	8-24-06	7450		
	Ekaterinburg	8-23-46	6100		
Sept. 27	Zi-ka-wei	7-01-18	2440	ϕ = 10° N	
1605	Pulkovo	7-01-10	9500	λ = 129° E	
	Ekaterinburg	7-01-14	7730	O = 7-01-14	
Sept. 30	Ottawa	1-20-56	3040	ϕ = 53°·0 N	
1608	Fordham	1-20-19	3280	λ = 33°·3 W	
	Honolulu	1-20-58	10350	O = 1-20-33	
	Tucson	1-20-49	6400		
	Cheltenham	1-20-37	3620		
	Sitka	1-20-26	6260		
	Porto Rico	1-20-45	4720		
	Ithaca	1-21-04	3000		
	Washington	1-20-40	3660		
	Northfield	1-21-16	2820		
	Chicago	1-20-55	3960		
	Victoria	1-19-27	6680		
	Georgetown	1-20-34	3700		
	Algiers	1-20-41	3200		
	Athens	1-20-34	4560		
	Strasbourg	1-20-02	3140		
	La Paz	1-20-44	8700		
	Uccle	1-20-40	2490		
	Lemberg	1-20-26	4560		
	Moncalieri	1-20-46	2930		
	Besançon	1-20-50	2780		
	Wien	1-19-35	4280		
	Barcelona	1-20-36	2970		
	De Bilt	1-20-29	2600		
	Belgrade	1-19-27	4850		
	Hamburg	1-20-16	3040		
	Pulkovo	1-20-47	3660		
	Ekaterinburg	1-20-47	5450		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 7	Honolulu..........	3-29-28	8360	ϕ = 1° N	
1613	Melbourne..........	3-28·8	4560	λ = 127° E	
	Wellington..........	3-29-33	6340	O = 3-29-33	
	Zi-ka-wei..........	3-29-52	3290	Location approximate.	
	Mizusawa..........	3-29-40	4460		
	Pulkovo..........	3-29-52	10250		
	Ekaterinburg........	3-29-38	8820		
Oct. 10	Ottawa..........	7-11-08	4460	ϕ = 70°·0 N	Uccle gives
1615	Toronto..........	7-10-57	4850	λ = 14°·0 W	ϕ = 70° N
	Helwan..........	7-11-11	5220	O = 7-11-11	λ = 14°·5 W.
	Ithaca..........	7-11-25	4520		
	Paris..........	7-11-19	2560		
	Georgetown..........	7-10-57	5350		
	Tucson..........	7-10-42	7120		
	Cheltenham..........	7-10-52	5310		
	Washington..........	7-11-13	5360		
	Chicago..........	7-11-06	5320		
	Algiers..........	7-11-15	3800		
	Athens..........	7-11-08	4100		
	Strasbourg..........	7-10-54	2840		
	Uccle..........	7-11-22	2340		
	Königsberg..........	7-11-12	2380		
	Lemberg..........	7-11-00	2960		
	Cartuja..........	7-11-18	3680		
	Moncalieri..........	7-11-27	2900		
	Pulkovo..........	7-11-04	2320		
	Besançon..........	7-11-17	2770		
	Innsbruck..........	7-11-16	2850		
	Stonyhurst..........	7-12·1	1810		
	Wien..........	7-11-08	2920		
	Ekaterinburg........	7-11-11	3410		
	Barcelona..........	7-11-07	3370		
	De Bilt..........	7-11-18	2270		
	Coimbra..........	7-11-21	3300		
	Belgrade..........	7-10-40	3700		
	Hamburg..........	7-11-12	2260		
Nov. 2	Sitka..........	21-08-49	9230	ϕ = 1° S	Apia gives
1628	Tucson..........	21-08-47	10050	λ = 157° E	ϕ = 6° S
	Honolulu..........	21-08-53	5520	O = 21-08-48	λ = 156° E.
	Victoria..........	21-08-57	9000	Location approximate.	
	Wellington..........	21-08-45	4120		Ekaterinburg gives
	Apia..........	21-08-38	3810		ϕ = 1° 27′ S
	Zi-ka-wei..........	21-08-49	4370		λ = 151° 35′ E.
	Lick..........	21-09-32	8620		
	Berkeley..........	21-09-07	9200		
	Pulkovo..........	21-08-25	12000		
	Ekaterinburg........	21-08-08	10200		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 3 1631	Ottawa	8-37-43	2820	ϕ = 19° N	
	Ithaca	8-37-44	2560	λ = 72° W	
	Toronto	8-37-21	2890	O = 8-37-48	
	Washington	8-37-45	2170		
	Chicago	8-38-03	2620		
	Porto Rico	8-37-53	660		
	Georgetown	8-37-44	2220		
	La Paz	8-37-41	3930		
	Port au Prince	8-37-43	225		
	Moncalieri	8-38-02	7500		
	Coimbra	8-38-07	6150		
Nov. 3 1632	Victoria	16-19-19	8680	ϕ = 29°·3 N	
	Jinsen	16-19-49	990	λ = 130°·5 E	
	Strasbourg	16-19-09	9700	O = 16-19-19	
	Kobe	16-19-32	700		
	Uccle	16-19-14	9650		
	Zi-ka-wei	16-19-24	810		
	Moncalieri	16-19-32	9660		
	Innsbruck	16-19-01	10120		
	Eskdalemuir	16-19-09	9780		
	Wien	16-19-18	9250		
	De Bilt	16-19-13	9660		
	Belgrade	16-19-09	9440		
	Pulkovo	16-19-20	7780		
	Ekaterinburg	16-19-15	6080		
Nov. 4 1633	Victoria	0-04-57	9350	ϕ = 4° S	
	Honolulu	0-04-18	6050	λ = 154° E	
	Jinsen	0-04-25	5380	O = 0-04-32	
	Taihoku	0-04-21	4740		
	Wellington	0-04-35	4340		
	Apia	0-04-31	3820		
	Zi-ka-wei	0-04-18	5200		
	Berkeley	0-04-40	10050		
	Ekaterinburg	0-04-41	10230		

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 5	Kobe	21-27-56	750	ϕ = 28°·5 N	Taihoku gives
1639	Helwan	21-28-01	9100	λ = 132°·5 E	ϕ = 28° 45′ N
	Paris	21-28-16	9450	O = 21-57-55	λ = 130° 15′ E.
	Jinsen	21-26-07	1330		
	Victoria	21-28-29	8440		Ekaterinburg gives
	Athens	21-27·5	9650		ϕ = 25° 44′ N
	Pulkovo	21-27-45	8000		λ = 127° 18′ E.
	Ekaterinburg	21-27-42	6240		
	Strasbourg	21-28-15	9150		
	Uccle	21-27-53	9660		
	Taihoku	21-27-45	1100		
	Zi-ka-wei	21-27-38	960		
	Innsbruck	21-28·0	9650		
	Eskdalemuir	21-28-19	9380		
	Stonyhurst	21-28·5	9400		
	Wien	21-27-50	9320		
	Coimbra	21-27-43	10430		
	Belgrade	21-28-07	9050		
	Hamburg	21-28-21	9080		
	Cartuja	21-28-10	10420		
Nov. 6	Zi-ka-wei	19-19-18	1040	ϕ = 30° N	Ekaterinburg gives
1641	Pulkovo	19-18-39	7750	λ = 132°·5 E	ϕ = 28° 44′ N
	Ekaterinburg	19-18-32	6110	O = 19-18-34	λ = 129° 38′ E.
	Jinsen	19-18-45	910		
	Kobe	19-18-36	830		
Nov. 17	Ottawa	2-52-49	7120	ϕ = 51° N	
1653	Toronto	2-53-19	6800	λ = 180° W	
	Victoria	2-53-16	3650	O = 2-53-02	
	Georgetown	2-52-24	7920		
	Zi-ka-wei	2-53-09	5220		
	Pulkovo	2-53-14	7430		
Nov. 18	Victoria	21-29-19	9680	ϕ = 23° N	
1654	Jinsen	21-29-19	1630	λ = 129° E	
	Pulkovo	21-29-38	7750	O = 21-29-25	
	Ekaterinburg	21-29-23	6040	Location doubtful.	

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 25 1657	Strasbourg..........	17–02·9	10050	ϕ = 23° N	Ekaterinburg gives
	Uccle..............	17–03–33	9340	λ = 120° E	ϕ = 22°·7 N
	Zi-ka-wei...........	17–03–12	850	O = 17–03–16	λ = 118°·7 E.
	De Bilt.............	17–03–21	9540	Location approximate.	
	Pulkovo............	17–03–23	7770		
	Ekaterinburg........	17–03–17	6000		
Dec. 5 1663	Ottawa.............	20–56–56	7640	ϕ = 40°·5 N	Uccle gives
	Algiers.............	20–56–56	1750	λ = 24°·8 E	ϕ = 39° N.
	Athens..............		225	O = 20–56–43	λ = 23° E.
	Barcelona...........	20–56–27	1950		
	Belgrade...........	20–57–23	450		Ekaterinburg gives
	Cartuja............	20–56–36	2450		ϕ = 41° 41′ N
	Coimbra...........	20–56–44	3180		λ = 22° 51′ E.
	Hamburg...........	20–56–42	1900		
	La Paz.............	20–57–38	11700		
	Strasbourg..........	20–56–32	1750		
	Uccle..............	20–56–41	1970		
	Wien..............	20–56–57	1050		
	Ekaterinburg........	20–56–35	3160		
	Pulkovo............	20–57–02	2100		
	Mostar.............	20–56–45	675		
	Sarajevo...........	20–56–47	680		
	Sinj...............	20–56–53	680		
	Travnik............	20–57–08	510		
	Helwan............	20–57–22	1030		
	Ithaca.............	20–56–06	8300		
	Lemberg...........	20–55–51	1420		
	Eskdalemuir........	20–56–47	2520		
	Innsbruck..........	20–55–44	1820		
	Stonyhurst..........	20–56–52	2510		
Dec. 5 1664	Osaka..............	22–34–16	4800	ϕ = 5°·5 S	
	Ekaterinburg........	22–35–06	8420	λ = 117°·5 E	
	Pulkovo............	22–35–11	10550	O = 22–34–47	
	Kobe..............	22–34–34	4820	Location and O approximate.	
Dec. 7 1665	Ekaterinburg........	15–53–11	5530	ϕ = 54° N	
	Pulkovo............	15–53–11	6640	λ = 160° E	
	Kobe..............	15–53–02	2900	O = 15–53–08	

LOCATION OF EPICENTRES, 1923

Date	Station	O	Δ	Epicentre	Other Locations
Dec. 14 1668	Ottawa............	10-30-55	5080	ϕ = 0°	
	Cartuja............	10-31-20	8850	λ = 79°·2 W	
	La Paz............	10-31-19	2200	O = 10-31-16	
	Rio de Janeiro.......	10-31-30	4370		
Dec. 27 1675	Hamburg...........	14-38-45	9400	ϕ = 36°·2 N	Pulkovo gives
	Strasbourg..........	14-38-46	9800	λ = 143°·8 E	ϕ = 35° 14′ N
	Wien...............	14-39-25	8980	O = 14-38-57	λ = 139° 44′ E.
	Zi-ka-wei...........	14-38-54	1950		
	Pulkovo............	14-39-01	7650		Ekaterinburg gives
	Irkutsk............	14-38-33	3480		ϕ = 35° 45′ N.
	Kobe..............	14-39-05	580		λ = 139° 22′ E.
	Tyosi..............	14-39-17	75		
	Eskdalemuir........	14-39-12	9140		Irkutsk gives
	Nagasaki...........	14-39-08	980		ϕ = 40° 44′ N
	Ekaterinburg........	14-38-24	6100		λ = 142° 38′ E.
Dec. 28 1676	Cartuja............	22-24-43	6110	ϕ = 42° N	Ekaterinburg gives
	Hamburg...........	22-24-32	4700	λ = 70° E	ϕ = 41° 16′ N
	Ekaterinburg........	22-24-24	1860	O = 22-24-43	λ = 70° 11′ E.
	Pulkovo............	22-24-45	3300		
	Irkutsk............	22-25-18	2680		Pulkovo gives
	Helwan............	22-24-38	3520		ϕ = 39° 12′ N
					λ = 64° 55′ E.

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Jan. 7 1678	Pulkovo............	9-55-45	7240	ϕ = 55°·5 N	Pulkovo gives Alaska.
	Ekaterinburg........	9-55-40	7040	λ = 158°·2 W	
	Uccle..............	9-56·3	7960	O = 9-55-55	
	Victoria............	9-55-57	2500		
Jan. 10 1679	Ekaterinburg........	23-43-49	5750	ϕ = 42° N	
	Pulkovo............	23-43-57	7450	λ = 140° E	
	Mizusawa...........	23-44-01	270	O = 23-43-55	
				Location approximate.	
Jan. 14 1682	Ottawa.............	20-51-07	9300	ϕ = 36°·5 N	Felt in Tokyo and
	Belgrade...........	20-50-21	9150	λ = 139°·2 E	Yokohama.
	Hamburg............	20-50-22	8950	O = 20-50-30	
	Strasbourg..........	20-50-41	9120		Pulkovo gives
	Sydney.............	20-50-16	7760		ϕ = 36° 23′ N
	Toronto............	20-51-17	9230		λ = 138° 41′ E.
	Uccle..............	20-50-31	9200		
	Victoria............	20-50-32	7460		Ekaterinburg gives
	Wien...............	20-50-15	9150		ϕ = 35° 19′ N
	Zi-ka-wei...........	20-50-09	1790		λ = 137° 34′ E.
	Dairen.............	20-50-49	1730		
	Zürich.............	20-50-40	9160		
	Rocca di Papa.......	20-50-46	9250		
	Ksara..............	20-50-34	8800		
	Sarajevo............	20-50-31	9150		
	Jinsen..............	20-51-55	1150		
	Pulkovo............	20-50-27	7480		
	Ootomari...........	20-49-52	1475		
	Mizusawa...........	20-50-24	420		
	Batavia............	20-50-11	5600		
	Helwan.............	20-50-31	9240		
	Lemberg............	20-49-48	8920		
	Manila.............	20-49-01	3750		
	Paris..............	20-50-45	9220		
	Perth..............	20-50-00	8250		
	Eskdalemuir........	20-50-40	8980		
	Firenze............	20-50-58	9080		
	Innsbruck..........	20-50-00	9980		
	Königsberg..........	20-50-26	8350		
	Nagasaki...........	20-50-20	910		
	Naples.............	20-51-05	9000		
	Stonyhurst..........	20-50-25	9250		
	Wellington..........	20-51-10	8800		
Jan. 16 1684	Osaka..............	21-37-50	7650	ϕ = 22°·5 S	Zürich gives
	Sydney.............	21-37-59	2810	λ = 177°·5 E	ϕ = 15° N
	Batavia............	21-37-56	7750	O = 21-37-59	λ = 155° E.
	Perth..............	21-38-12	5920		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Jan. 21	Eskdalemuir........	1-52-49	7280	ϕ = 57° N	Pulkovo gives
1686	Innsbruck..........	1-53-00	7750	λ = 150°·5 E	ϕ = 57° 10′ N
	Königsberg.........	1-52-53	6710	O = 1-52-53	λ = 150° 19′·4 E.
	Batavia............	1-52-53	7650		
	Helwan............	1-52-56	8720		Ekaterinburg gives
	Paris..............	1-52-55	7800		ϕ = 55°·6 N
	Barcelona..........	1-52-45	8650		λ = 149°·4 E.
	Cartuja............	1-53-01	9050		
	Hamburg...........	1-52-49	7240		
	Osaka..............	1-53-05	2350		Zürich gives
	Strasbourg..........	1-52-55	7700		ϕ = 57° N
	Uccle..............	1-52-58	7500		λ = 152° E.
	Wien...............	1-52-47	7660		
	Rocca di Papa.......	1-52-56	8200		
	Pulkovo............	1-52-50	5990		
	Ekaterinburg........	1-52-48	5060		
	Zürich.............	1-52-48	7920		
	Toledo.............	1-52-50	8870		
	Tyosi..............	1-52-41	2220		
	Ootomari...........	1-52-56	1285		
	Mizusawa...........	1-52-59	1910		
	Tortosa............	1-52-55	8650		
Jan. 29	Ottawa.............	1-55-02	8120	ϕ = 28°·5 S	La Paz gives
1688	Georgetown.........	1-54-54	7460	λ = 74°·5 W	La Serena,
	La Paz.............	1-54-23	1520	O = 1-54-57	Chile.
	Toronto............	1-54-58	7950		
	Victoria...........	1-54-56	9820		
	Ithaca.............	1-54-51	7900		
	Wellington.........	1-55-33	9280		
Feb. 13	Ekaterinburg........	22-50-21	8460	ϕ = 4° N	Manila gives
1693	Pulkovo............	22-50-50	9520	λ = 125° E	Celebes sea.
	Manila.............	22-51-14	1440	O = 22-50-48	
				Location approximate.	
Feb. 18	Athens.............	17-03-20	1350	ϕ = 36° N	Ekaterinburg gives
1698	Cartuja............	17-03-54	3550	λ = 36°·8 E	ϕ = 36° 10′ N
	Hamburg...........	17-03-27	3000	O = 17-03-49	λ = 35° 44′ E.
	Strasbourg..........	17-03-53	2610		
	Uccle..............	17-03-48	2920		
	Wien...............	(17-03-35)	2270		Pulkovo gives
	Zürich.............	17-03-52	2510		ϕ = 36° N
	Toledo.............	17-04-02	3200		λ = 35° E.
	Pulkovo............	17-03-57	2690		
	Helwan............	17-03-53	600		Königsberg gives
	Firenze............	17-04-20	2020		ϕ = 36° N
	Innsbruck..........	17-03-49	2380		λ = 38° E.
	Königsberg.........	17-03-48	2510		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Feb. 19	Athens	6–59–48	2200	ϕ = 40° N	Pulkovo reports quake felt
1699	Belgrade	6–59–46	2400	λ = 48°·5 E	at Lenkoran, Persia.
	Cartuja	6–59–46	4550	O = 6–59–48	
	Uccle	6–59·4	3650		
	Zürich	6–59–53	3120		Königsberg gives
	Toledo	6–59–49	4280		ϕ = 37° N
	Pulkovo	6–59–55	2540		λ = 48° E.
	Helwan	6–59–45	1930		
	Eskdalemuir	6–59–33	4120		
	Königsberg	7–00–17	2550		
Feb. 24	Victoria	5–45–17	560	ϕ = 44°·2 N	
1702	Ekaterinburg	5–45–13	8720	λ = 127°·2 W	
	Pulkovo	5–45–31	8150	O = 5–45–20	
Mar. 4	Ottawa	10–07–40	3900	ϕ = 10°·5 N	Hamburg, Victoria, Inns-
1706	Algiers	10–07–54	9060	λ = 84° W	bruck and Wellington
	Athens	10–07–48	10050	O = 10–07–49	give San Jose,
	Barcelona	10–08–09	8840		Costa Rica.
	Cartuja	10–07–51	8600		
	Georgetown	10–07–29	3250		
	Hamburg	10–07–48	9380		
	La Paz	10–07–51	3230		
	Strasbourg	10–07–45	9340		
	Toronto	10–07–34	3700		
	Uccle	10–07–49	9060		
	Victoria	10–07–26	5880		
	Wien	10–08–10	9500		
	Tortosa	10–07–49	8950		
	San Fernando	10–07–46	8450		
	Zürich	10–07–47	9400		
	Padova	10–07–57	9550		
	Rocca di Papa	10–07–58	9700		
	Cheltenham	10–08–03	3040		
	Ithaca	10–07–38	3600		
	Paris	10–07–53	8940		
	Rio de Janeiro	10–07–40	5720		
	Tucson	10–07–36	3660		
	Naples	10–08–04	9000		
	Innsbruck	10–07–55	9620		
	Porto Rico	10–07–53	2220		
Mar. 4	Porto Rico	11–43–52	2220	ϕ = 10° N	La Paz gives
1707	Tucson	11–44–56	3140	λ = 84°·5 W	Costa Rica.
	Ottawa	11–43–54	3780	O = 11–44–02	
	Cartuja	11–44–03	8630		
	La Paz	11–43–43	3350		
	St asbourg	11–43–43	9440		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Mar. 11 1715	Algiers	10–41–23	9000	ϕ = 10° N	Wien gives
	Cartuja	10–41–27	8500	λ = 84° W	ϕ = 2° N
	Hamburg	10–41–30	9200	O = 10–41–18	λ = 77° W.
	La Paz	10–41–02	3410		
	Strasbourg	10–41–17	9300		Toledo gives Costa Rica.
	Wien	10–41–14	9980		
	Porto Rico	10–41–01	2320		
	Toledo	10–41–14	8550		
Mar. 12 1719	Strasbourg	13–52–31	2810	ϕ = 75° N	Zürich gives
	Uccle	13–52–47	2420	λ = 7°·8 E	ϕ = 82° N
	Wien	13–52–23	3000	O = 13–52–38	λ = 0° E.
	Baku	13–52–43	4300		
	Paris	13–52–46	2640		Strasbourg gives Arctic ocean—vicinity Spitzbergen.
Mar. 15 1722	Athens	10–31–23	8680	ϕ = 47°·2 N	Strasbourg gives
	Belgrade	10–31–34	8120	λ = 140°·8 E	ϕ = 47° N
	Cartuja	10–30–56	10010	O = 10–31–21	λ = 142° E.
	Georgetown	10–31–38	9280		
	Strasbourg	10–31–21	8400		Cartuja and Belgrade give Sakhalin I.
	Sydney	10–31–25	9210		
	Uccle	10–31–25	8200		
	Victoria	10–31–10	6520		
	Wien	10–31–15	8200		Zürich gives
	Zi-ka-wei	10–31–40	2390		ϕ = 48° N
	Taihoku	10–31–03	3360		λ = 145° E.
	Toledo	10–31–35	9320		
	Jinsen	10–31–46	1640		
	Ootomari	10–31–22	260		
	Baku	10–31–16	7050		
	Batavia	10–31–19	7100		
	Helwan	10–31–31	8840		
	Honolulu	10–31–04	6300		
	Manila	10–31–12	4250		
	Paris	10–31–51	8160		
	Perth	10–31–30	9300		
	Sitka	10–30–51	5560		
	Firenze	10–31–18	8700		
	Innsbruck	10–31–20	8420		
	Wellington	10–31–03	10700		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Mar. 16 1723	La Paz	1-21-45	2210	ϕ = 2° N	
	Strasbourg	1-22-49	9400	λ = 76° W	
	Toronto	1-23-46	4320	O = 1-22-37	
	Uccle	1-22-52	9060		
	Paris	1-21·9	9900		
Mar. 16 1724	Eskdalemuir	10-17-42	2220	ϕ = 34° N	Königsberg gives Algiers.
	Helwan	10-17-05	2620	λ = 4°·8 E	
	Paris	10-17-10	1670	O = 10-17-22	
	Algiers	10-17-18	360		Toledo gives
	Toledo	10-17-20	1040		ϕ = 34°·5 N
	Cartuja	10-17-29	880		λ = 7° E.
	Hamburg	10-17-46	1860		
	Strasbourg	10-17-08	1680		
Mar. 24 1729	Ottawa	20-28-16	4300	ϕ = 7° N	Zürich gives off coast of Columbia.
	Cartuja	20-29-04	8700	λ = 83° W	
	La Paz	20-29-30	3050	O = 20-29-02	
	Strasbourg	20-29-12	9310		
	Porto Rico	20-29-07	2300		
Mar. 25 1731	Ottawa	14-06-49	3900	ϕ = 10°·5 N	Strasbourg and Toledo give Central America.
	Cartuja	14-07-04	8450	λ = 84°·5 W	
	Hamburg	14-06-55	9480	O = 14-06-54	
	La Paz	14-06-42	3380		
	Strasbourg	14-06-54	9350		
	Toronto	14-06-15	4220		
	Uccle	14-07-02	9010		
	Wien	14-07-06	9750		
	Toledo	14-07-01	8520		
	Moncalieri	14-07-12	9350		
	Paris	14-07-06	8850		
	Porto Rico	14-06-43	2300		
Mar. 25 1732	Ottawa	15-03-00	4060	ϕ = 10°·5 N	
	Cartuja	15-03-35	8550	λ = 86° W	
	Hamburg	15-03-46	9150	O = 15-03-23	
	La Paz	15-03-05	3560		
	Strasbourg	15-03-25	9300		
	Toledo	15-03-29	8520		
April 13 1745	Osaka	13-48-06	4000	ϕ = 3°·5 N	Batavia gives NE. Borneo.
	Sydney	13-48-02	5050	λ = 116° E	
	Zi-ka-wei	13-48-09	3120	O = 13-48-06	

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
April 14 1747	Belgrade	16–21–30	9500	$\phi = 6°\cdot 8$ N	Manila gives
	Osaka	16–20–02	3500	$\lambda = 122°\cdot 5$ E	$\phi = 6° 58'$ N
	Strasbourg	16–20–42	11080	O = 16–20–32	$\lambda = 126° 12'$ E
	Wien	16–20–33	10750		
	Zi-ka-wei	16–20–45	2480		
	Sydney	16–20–20	5210		
	Ksara	16–20–44	9500		
	Tyosi	16–20–05	3680		
	Mizusawa	16–20–36	3660		
	Cheltenham	16–20–29	14300		
	Honolulu	16–20–05	8900		
	Perth	16–20–34	4280		
	Helwan	16–21–03	9440		
	Tucson	16–20–15	12100		
	Porto Rico	16–20–23	16700		
April 20 1752	Algiers	14–26–56	5400	$\phi = 15°\cdot 5$ N	Königsberg gives
	Athens	14–27–03	3600	$\lambda = 53°$ E	$\phi = 15°$ N
	Cartuja	14–27–00	6000	O = 14–26–55	$\lambda = 50°$ E.
	Hamburg	14–26–57	5680		
	Strasbourg	14–26–55	5500		
	Uccle	14–26–56	5870		
	Wien	14–26–52	4950		
	Tortosa	14–27–12	5630		
	Toledo	14–26–54	6150		
	Moncalieri	14–26–31	5380		
	San Fernando	14–26–17	6640		
	Batavia	14–27–01	6450		
	Helwan	14–26–48	2810		
	Paris	14–27–02	5800		
	Eskdalemuir	14–26–59	6500		
	Innsbruck	14–27–02	5100		
	Königsberg	14–27–08	5070		
April 21 1753	Ottawa	20–01–09	3440	$\phi = 20°$ N	
	Barcelona	20–01–03	9370	$\lambda = 100°$ W	
	Cartuja	20–00–54	9350	O = 20–01–04	
	Georgetown	20–00–31	3480		
	La Paz	20–00–43	5320		
	Strasbourg	20–01–03	9650		
	Toronto	20–00–55	3180		
	Uccle	20–01–07	9220		
	Toledo	20–01–03	9160		
	Moncalieri	20–00–21	9970		
	Tortosa	20–01–13	9280		
	Cheltenham	20–01–23	3050		
	Honolulu	20–01–19	5700		
	Paris	20–01–13	9100		
	Tucson	20–01–29	1720		
	Denver	20–01–17	1750		
	Porto Rico	20–01–20	3420		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
April 29 1759	Hamburg..........	20-51-45	8220	ϕ = 52° N	
	Osaka............	20-51-31	3240	λ = 170° W	
	Strasbourg..........	20-51-48	8700	O = 20-51-42	
	Uccle..............	20-52·0	8320		
	Zi-ka-wei..........	20-51-01	4600		
	Innsbruck..........	20-52-11	8250		
May 1 1763	Ottawa............	19-54-20	3690	ϕ = 12°·5 N	
	Algiers............	19-54-33	9200	λ = 88° W	
	Barcelona..........	19-54-29	9100	O = 19-54-27	
	Cartuja............	19-54-29	8740		
	Georgetown.........	19-54-02	3120		
	Hamburg...........	19-54-30	9320		
	La Paz............	19-54-08	3900		
	Strasbourg..........	19-54-37	9150		
	Toronto...........	19-54-25	3350		
	Uccle..............	19-54-24	9090		
	Victoria...........	19-54-17	5030		
	Wien..............	19-54-48	9480		
	Toledo............	19-54-23	8560		
	Tortosa............	19-54-30	8680		
	San Fernando.......	19-54-30	8560		
	Zürich............	19-54-42	9230		
	Padova............	19-54-42	9300		
	Moncalieri..........	19-55-05	9060		
	Honolulu..........	19-54-11	6780		
	Halifax............	19-54-22	4140		
	Ithaca............	19-53-36	3900		
	Paris..............	19-54-27	9060		
	Rio de Janeiro.......	19-54-20	6300		
	Sitka.............	19-54-16	6450		
	Innsbruck..........	19-54·7	9400		
	Königsberg.........	19-54-56	9370		
	Porto Rico.........	19-54-37	2330		
	Stonyhurst..........	19-54-28	8600		
May 4 1766	Ottawa............	16-57-55	6180	ϕ = 55° N	
	Barcelona..........	16-58-26	9210	λ = 165° W	
	Firenze...........	16-58-39	8820	O = 16-58-21	
	Tortosa............	16-58-25	9190		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
May 6 1771	Athens	16-09-53	9080	ϕ = 15° N	
	Belgrade	16-09-50	9150	λ = 119°·5 E	
	Hamburg	16-09-03	9900	O = 16-09-29	
	Osaka	16-09-15	2700		
	Wien	16-09-29	9600		
	Zi-ka-wei	16-09-31	1650		
	Ksara	16-09-29	8550		
	Jinsen	16-09-09	2590		
	Mizusawa	16-09-22	3190		
	Helwan	16-09-35	8850		
	Lemberg	16-09-04	9200		
	Perth	16-09-55	4980		
	Innsbruck	16-09-42	9550		
May 13 1779	Innsbruck	1-51-50	3000	ϕ = 40° N	Zürich gives Erzerum.
	Athens	1-51-39	2100	λ = 44° E	
	Cartuja	1-52-44	3880	O = 1-52-14	
	Hamburg	1-52-13	2980	Location approximate.	
	Toledo	1-52-44	3880		
May 17 1781	Toronto	5-25-14	8880	ϕ = 47° N	
	Victoria	5-30-51	6450	λ = 152° E	
	Wien	5-22-16	8980	O = 5-24 ca.	
	Zi-ka-wei	5-17-54	2460	Location approximate.	
May 21 1784	Ottawa	10-12-48	3600	ϕ = 14°·5 N	
	La Paz	10-13-08	3960	λ = 86° W	
	Toronto	10-12-52	3280	O = 10-12-38	
	Victoria	10-11-46	4820		
May 27 1790	La Paz	10-13-46	3840	ϕ = 21° N	Porto Rico gives Port de Paix, Haiti.
	Toronto	10-12-04	3270	λ = 72° W	
	Ithaca	10-14-32	2480	O = 10-13·5 ca.	

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
May 28 1792	Ottawa............	9-52-00	7960	ϕ = 54° N	Zürich gives
	Algiers............	9-51-55	8740	λ = 142° E	ϕ = 54° N
	Belgrade...........	9-51-34	7920	O = 9-51-56	λ = 142° E.
	Cartuja............	9-51-52	9200		
	Georgetown.........	9-51-58	8550		
	Hamburg............	9-51-50	7350		
	Strasbourg.........	9-51-51	7850		
	Toronto............	9-52-01	8000		
	Uccle..............	9-51-52	7720		
	Wien...............	9-51-52	7600		
	Osaka..............	9-52-28	1400		
	Zi-ka-wei..........	9-51-50	2300		
	Zürich.............	9-51-54	7920		
	Rocca di Papa......	9-51-57	8220		
	Rome...............	9-51-53	8300		
	Ootomari...........	9-51-52	430		
	Moncalieri.........	9-52-10	8060		
	Batavia............	9-52-10	6180		
	Helwan.............	9-52-03	8250		
	Honolulu...........	9-52-03	5000		
	Lemberg............	9-51-43	7140		
	Paris..............	9-51-54	7950		
	Innsbruck..........	9-51-58	7760		
	Königsberg.........	9-51-56	6780		
June 4 1795	Paris..............	16-09-33	9480	ϕ = 15°·5 N	
	Hamburg............	16-09-52	9450	λ = 95°·5 W	
	Strasbourg.........	16-09-27	9860	O = 16-09-42	
	Uccle..............	16-09-47	9230		
	Victoria...........	16-09-51	4400		
June 22 1803	Ottawa............	22-29-04	4320	ϕ = 6° N	
	La Paz.............	22-29-01	2620	λ = 77°·5 W	
	Toronto............	22-28-57	4200	O = 22-29-05	
	Uccle..............	22-29-16	8880		
	Victoria...........	22-29-00	6350		
	Eskdalemuir........	22-29-15	8500		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
June 30	Ottawa	15-44-30	8780	$\phi = 47°\cdot5$ N	Wien gives
1812	Algiers	15-44-27	9860	$\lambda = 149°$ E	$\phi = 47°$ N
	Barcelona	15-44-26	9500	O = 15-44-30	$\lambda = 150°$ E.
	Belgrade	15-44-29	8580		
	Cartuja	15-44-30	9950		Chur gives
	Georgetown	15-44-31	9340		$\phi = 47°$ N
	Hamburg	15-44-21	8200		$\lambda = 150°$ E.
	Osaka	15-44-53	1220		
	Strasbourg	15-44-16	8780		Manila gives
	Toronto	15-44-32	8780		Pacific near Kurile Is.
	Uccle	15-44-23	8580		
	Victoria	15-44-16	6250		
	Wien	15-44-26	8400		
	Zi-ka-wei	15-44-32	2430		
	Moncalieri	15-44-57	8950		
	Ksara	15-44-38	8470		
	Oxford	15-44-34	8580		
	Florence	15-44-30	8940		
	Rocca di Papa	15-44-32	9000		
	Tortosa	15-44-49	9150		
	Munich	15-44-28	8550		
	Naples	15-44-45	9050		
	Padova	....	9000		
	Ischia	15-44-11	9050		
	Chur	15-44-26	8840		
	Ootomari	15-44-27	420		
	Sarajevo	15-44-32	8740		
	Mizusawa	15-44-37	710		
	Batavia	15-44-22	6780		
	Cheltenham	15-44-46	9060		
	Helwan	15-44-37	9000		
	Ithaca	15-44-31	9000		
	Lemberg	15-44-08	8200		
	Paris	15-44-19	8940		
	Sitka	15-44-17	5080		
	Tucson	15-45-05	7820		
	Eskdalemuir	15-44-23	8380		
	Innsbruck	15-44-46	8260		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
July 3 1815	Ottawa	4-40-57	9560	ϕ = 36° N	Stonyhurst and Strasbourg give Tibet.
	Stonyhurst	4-39-58	6710	λ = 86° E	
	Nagasaki	4-40-09	4020	O = 4-40-10	
	Königsberg	4-40-04	5050		
	Firenze	4-39-48	6320		Königsberg and Trenta give Himalayas.
	Eskdalemuir	4-40-05	6620		
	Helwan	4-40-04	4820		
	Manila	4-40-11	4260		
	Paris	4-40-18	6300		Zürich gives
	Sitka		8160		ϕ = 30° N
	Perth	4-40-22	8260		λ = 80° E.
	Algiers	4-40-02	7140		
	Athens	4-40-00	5310		
	Barcelona	4-40-08	6850		
	Belgrade	4-39-47	5550		
	Cartuja	4-41-30	6820		
	Chicago	4-41-26	9520		
	Coimbra	4-40-02	7850		
	Hamburg	4-39-54	5980		
	Osaka	4-40-24	4350		
	Strasbourg	4-39-59	6220		
	Toronto	4-41-14	9550		
	Uccle	4-40-03	6320		
	Victoria	4-40-38	9580		
	Wien	4-39-52	5680		
	Zi-ka-wei	4-40-09	3300		
	Munich	4-40-02	5900		
	Toledo	4-40-03	7530		
	Valle di Pompei	4-38-50	5880		
	Kobe	4-40-12	4400		
	Taihoku	4-40-00	3740		
	Aberdeen	4-40-08	6460		
	West Bromwich	4-40-05	6640		
	Oxford	4-40-17	6500		
	Mizusawa	4-40-05	4830		
	Padova	4-39-10	5850		
	Trenta	4-40-06	5880		
	San Fernando	4-39-54	8050		
	Tortosa	4-40-03	7100		
	Rocca di Papa	4-39-58	6080		
	Piacenza	4-40-11	6080		
	Jinsen	4-40-06	3530		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
July 6	Ottawa	14-18-32	4220	ϕ = 8° N	Königsberg and Wien give
1818	Cartuja	14-18-44	8250	λ = 78° W	ϕ = 7° N
	Chicago	14-18-41	3910	O = 14-18-46	λ = 78° W
	Coimbra	14-18-47	7780		Panama.
	Georgetown	14-18-39	3410		
	Hamburg	14-18-56	9100		
	La Paz		2920		
	Strasbourg	14-18-48	9100		
	Toronto	14-18-46	3840		
	Uccle	14-18-51	8820		
	Victoria	14-18-39	6280		
	Wien	14-18-44	9780		
	Toledo	14-18-41	8260		
	Rocca di Papa	14-18-54	9400		
	Tortosa	14-18-58	8480		
	Halifax	14-18-33	4400		
	Moncalieri	14-19-05	9150		
	Honolulu	14-19-04	8640		
	Ithaca	14-18-39	3810		
	Paris	14-18-43	8850		
	San Fernando	14-19-09	7800		
	Rio de Janeiro	14-18-37	4920		
	Eskdalemuir	14-18-51	8360		
	Porto Rico	14-18-21	2020		
July 6	Algiers	18-31-31	6200	ϕ = 43° N	Königsberg gives highlands
1819	Athens	18-31-06	4680	λ = 75° E	of Pamir.
	Barcelona	18-31-48	5770	O = 18-31-43	
	Belgrade	18-31-46	4210		
	Cartuja	18-31-41	6650		Zürich gives
	Coimbra	18-31-48	6640		ϕ = 37° N
	Hamburg	18-31-44	4780		λ = 70° E.
	Osaka	18-32-00	5300		
	Strasbourg	18-31-41	5070		Belgrade gives Turkestan.
	Uccle	18-31-41	5280		
	Wien	18-31-23	4720		
	Zi-ka-wei	18-31-27	4120		
	Padova	18-30-44	4880		
	Oxford	18-32-05	5420		
	Tortosa	18-31-49	5900		
	Toledo	18-31-47	6320		
	San Fernando	18-32-13	6540		
	Bergen	18-32-21	4860		
	Moncalieri	18-32-05	5160		
	Helwan	18-31-32	4000		
	Paris	18-31-31	5650		
	Eskdalemuir	18-31-59	5650		
	Firenze	18-31-47	4920		
	Königsberg	18-31-42	4020		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
July 11 1826	Algiers	19–44–36	7050	ϕ = 38° N	Uccle gives
	Barcelona	19–44–44	6760	λ = 86° E	ϕ = 38° N
	Belgrade	19–44–36	5310	O = 19–44–37	λ = 86° E.
	Cartuja	19–44–59	7420		
	Coimbra	19–44–47	7620		Eskdalemuir gives
	Hamburg	19–44–23	5980		ϕ = 37° N
	La Paz	19–44–44	15760		λ = 84° E.
	Osaka	19–44–53	4400		
	Strasbourg	19–44–13	6450		Stonyhurst, Belgrade and Königsberg give Tibet.
	Uccle	19–44–34	6280		
	Victoria	19–45–27	9250		
	Wien	19–44–55	5160		
	Zi-ka-wei	19–44–51	3180		
	Taihoku	19–44–49	3680		
	Aberdeen	19–44–24	6500		
	We t Bromwich	19–44–43	6580		
	Tortosa	19–44–37	7040		
	Rocca di Papa	19–44–18	6280		
	Jinsen	....	3450		
	Moncalieri	19–44–29	6380		
	Toledo	19–44–44	7340		
	San Fernando	19–44–03	8200		
	Padova	19–44–14	6340		
	München	19–44–31	5900		
	Piacenza	19–44–41	6080		
	Tyosi	19–44–54	4750		
	Neuchâtel	19–44–32	6300		
	Helwan	19–44–29	4880		
	Manila	19–44–40	4350		
	Paris	19–44–40	6420		
	Sitka	....	8750		
	Eskdalemuir	19–44–46	6500		
	Firenze	19–44–28	6220		
	Innsbruck	19–44–15	6250		
	Königsberg	19–44–14	6350		
	Stonyhurst	19–44–38	6680		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Localities
July 12 1827	Ottawa	15-12-38	9890	ϕ = 41° N	Zurich gives
	Algiers	15-12-02	6160	λ = 72°·5 E	ϕ = 40° N
	Barcelona	15-12-24	5870	O = 15-12-30	λ = 70° E.
	Coimbra	15-12-23	6750		
	Hamburg	15-12-28	4800		Strasbourg and Uccle give
	Strasbourg	15-12-25	5100		Turkestan.
	Uccle	15-12-29	5250		
	Victoria	15-12-59	9560		
	Wien	15-12-37	4300		Eskdalemuir gives
	Zi-ka-wei		4780		ϕ = 40° N
	Rocca di Papa	15-12-34	4830		λ = 72° E.
	Padova	15-12-49	4600		
	Piacenza	15 12-18	5220		
	München	15-12- 2	4750		
	Moncalieri	15-12-26	5180		
	Oxford	15 12 36	5520		
	Sa Fernando	15-12-17	6640		
	Tortosa	15-12-31	5960		
	Toledo	15-12-36	6300		
	Helwan	15-12-31	3840		
	Paris	15-12-32	5400		
	Eskdalemuir	15-12-26	5620		
	Stonyhurst	15-12-34	5560		
	Königsberg	15-12-28	4050		
July 22 1837	Ottawa	4-04-04	4880	ϕ = 2° N	
	Cartuja	4-04-22	8420	λ = 76°·5 W	
	Chicago	4-04-16	4450	O = 4-04-24	
	Coimbra	4-04-33	7860		
	Georgetown	4-04-18	4080		
	Hamburg	4-04-46	9020		
	La Paz	4-04-22	1860		
	Toronto	4-04-13	4650		
	Uccle	4-04-37	8820		
	Victoria	4-04-08	6820		
	Oxford	4-04-23	8800		
	Toledo	4-04-18	8420		
	Ithaca	4-04-19	4520		
	Eskdalemuir	4-04-30	8720		
	Stonyhurst	4-04-45	8520		
July 22 1839	Hamburg	14-24-02	9150	ϕ = 23°·5 N	
	Uccle	14-24-01	9440	λ = 122° E	
	Wien	14-23-59	9080	O = 14-24-06	
	Zi-ka-wei	14-23-55	810		
	Rocca di Papa	14-24-27	9060		Taihoku gives
	Padova	14-24-39	9100		ϕ = 23°·8 N
	Piacenza	14-24-37	9200		λ = 122°·3 E
	Ootomari	14-23-30	3540		
	Jinsen	14-23-54	1560		
	Manila	14-23-51	1050		
	Eskdalemuir	14-24-07	9560		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
July 24	Ottawa............	5–02–57	8550	ϕ = 50° N	
1841	Algiers............	5–02–39	9700	λ = 146° E	
	Chicago............	5–02–41	8540	O = 5–02–48	
	Toronto............	5–02–56	8540		
Aug. 10	Honolulu...........	6–12–12	5920	ϕ = 28°·5 S	
1851	Melbourne..........	6–11·7	3420	λ = 178°·5 W	
	Victoria............	6–12–17	9600	O = 6–12–05	
	Zi-ka-wei...........	6–12–08	9220	Location approximate.	
Aug. 13	Eskdalemuir........	13–30–30	8120	ϕ = 51° N	
1854	Hamburg...........	13–30–39	8220	λ = 175°·5 W	
	Paris..............	13–30–29	8840	O = 13–30–28	
	Toronto............	13–30–29	6760		
	Uccle..............	13–30–29	8620		
	Victoria............	13–30–17	3660		
Aug. 13	Eskdalemuir........	23–57–56	7560	ϕ = 33° N	
1855	Paris..............	23–57–54	7460	λ = 96° E	
	Uccle..............	23–57–49	7310	O = 23–57–53	
Aug. 14	Ottawa............	18–02–32	10140	ϕ = 37° N	Zürich gives
1856	Batavia............	18–02–41	5800	λ = 141°·5 E	ϕ = 43° N
	Belgrade...........	18–02–59	8880	O = 18–02–37	λ = 135° E.
	Besançon...........	18–02–25	9980		
	Cartuja............	18–02–43	10880		Tyosi gives Kashima sea.
	Chicago............	18–02–32	9340		
	Eskdalemuir........	18–02–40	9220		
	Hamburg...........	18–02–36	9080		Königsberg, Manila, Strasbourg, Uccle, Toledo and Malaga give Japan.
	Honolulu...........	18–02–24	6300		
	Königsberg.........	18–02–58	8160		
	Lemberg...........	18–02·5	8680		
	Manila.............	18–01–45	3740		
	Paris..............	18–02–47	9560		
	Stonyhurst.........	18–02–57	9400		
	Strasbourg.........	18–02–54	9450		
	Toronto............	18–01–49	10600		
	Uccle..............	18–02–33	9560		
	Victoria............	18–02–41	7380		
	Wien..............	18–03–13	8540		
	Zürich.............	18–02–45	9440		
	Ksara..............	18–02–57	8800		
	Nagasaki...........	18–01–56	1480		
	Tyosi..............		75		
	Bergen............	18–01–53	9080		
	Jinsen.............	18–02–42	1380		
	Taihoku............	18–02–26	2430		
	Firenze............	18–02–35	8620		
	Oxford.............	18–02–44	9550		
	Apia...............	18–03–12	7380		
	Ootomari...........	18–03–21	840		
	Padova.............	18–02–16	10150		
	Mizusawa..........	18–02–42	310		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 14	Batavia	23-27-27	5840	ϕ = 37° N	Königsberg, Manila, and
1857	Cartuja	23-28-07	10970	λ = 140°·2 E	Malaga give Japan.
	Eskdalemuir	23-27-33	9220	O = 23-27-42	
	Hamburg	23-27-26	9100		
	Königsberg	23-27-32	8500		
	Stonyhurst	23-27-58	8800		
	Strasbourg	23-27-50	9280		
	Uccle	23-27·7	9150		
	Victoria	23-27-31	7380		
	Ksara	23-27-58	8800		
	Ootomari	23-28-08	840		
	Kobe	23-27-22	700		
	Mizusawa	23-27-35	280		
	Jinsen	23-27-50	1220		
Aug. 17	Eskdalemuir	1-46-16	9100	ϕ = 36° N	Königsberg gives
1858	Uccle	1-46·2	9280	λ = 143° E	ϕ = 35° N
	Victoria	1-45-50	7530	O = 1-46-00	λ = 150° E.
	Zi-ka-wei	1-45-06	2410		
	Ootomari	1-45-35	880		
	Jinsen	1-47-03	1270		
Aug. 21	Cartuja	18-50-46	10220	ϕ = 51° N	
1861	Uccle	18-51·1	8550	λ = 180° W	
	Zi-ka-wei	18-50-47	5180	O = 18-50-53	
Aug. 25	Ottawa	14-31-27	9400	ϕ = 36° N	Königsberg gives
1865	Batavia	14-30-52	5960	λ = 142°·2 E	ϕ = 35° N
	Belgrade	14-30-55	9150	O = 14-31-02	λ = 145° E.
	Eskdalemuir	14-31-02	9250		
	Hamburg	14-31-03	8940		Tyosi reports quake felt
	Königsberg	14-31-01	8450		there.
	Manila	14-31-16	2850		
	Paris	14-31-03	9580		
	Stonyhurst	14-30-50	9550		
	Strasbourg	14-31-03	9520		
	Uccle	14-31-02	9350		
	Victoria	14-30-53	7480		
	Wien	14-31-06	9050		
	Zi-ka-wei	14-30-52	1980		
	Firenze	14-31-27	9400		
	Piacenza	14-31-06	9510		
	Nagasaki	....	1295		
	Tyosi	....	75		
	Kobe	14-30-48	740		
	Mizusawa	14-30-43	410		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 25 1866	Ottawa	23-06-58	7600	ϕ = 55° N	
	Cartuja	23-07-10	9600	λ = 164° E	
	Eskdalemuir	23-07-04	7700	O = 23-07-04	
	Königsberg	23-07-16	7300		
	Paris	23-07-06	8280		
	Strasbourg	23-07-09	8260		
	Uccle	23-07-02	8100		
	Victoria	23-07-09	4750		
	Wien	23-07-00	8200		
	Piacenza	23-06-54	8720		
	Toledo	23-07-12	9230		
	Rocca di Papa	23-07-09	8820		
	Firenze	23-06-58	8800		
	Mizusawa	23-06-56	2340		
Aug. 27 1867	Besançon	22-33-32	3040	ϕ = 63° N	Malaga gives Iceland.
	Cartuja	22-33-42	2420	λ = 25°·5 W	
	Eskdalemuir	22-33-52	2500	O = 22-33-46	
	San Fernando	22-33-36	2330	Location doubtful.	
	Uccle	22-33-48	2810		
	Malaga	22-33-49	2390		
	Rocca di Papa	22-34-05	3230		
Aug. 30 1870	Hamburg	3-05·6	10000	ϕ = 12° N	Königsberg gives
	Batavia	3-04-42	2800	λ = 125°·5 E	ϕ = 25° N
	Helwan	3-05-30	9340	O = 3-05-15	λ = 130° E
	Honolulu	3-05-04	8220		
	Melbourne	3-04·4	5780		Zurich gives Liu Kiu I.
	Perth	3-05-21	4280		
	Victoria	3-05-45	9750		
	Wien	3-05-47	9500		Taihoku gives Mindanao.
	Zi-ka-wei	3-05-32	2120		
	Apia	3-05-02	7480		
	Ksara	3-05-09	9340		
	Mizusawa	3-05-03	3440		
	Nagasaki	3-05-31	2395		
	Tyosi	....	2820		
	Jinsen	....	2820		
Sept. 4 1872	Cartuja	16-00-56	3330	ϕ = 65° N	Paris, Pulkovo and Strasbourg give Iceland.
	Hamburg	16-00-48	2420	λ = 25°·2 W	
	Paris	16-01-07	2330	O = 16-00-59	
	Pulkovo	16-01-02	2800		
	Strasbourg	16-00-58	2620		
	Uccle	16-01-03	2230		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Sept. 6	Ekaterinburg........	4–50–55	2320	ϕ = 39° N	
1874	Hamburg...........	4–50–37	3020	λ = 43° E	Ekaterinburg gives
	Königsberg.........	4–50–57	2350	O = 4–50–42	ϕ = 39° 29′ N
	Pulkovo............	4–50–53	2400		λ = 42° 49′ E.
	Ksara..............	4–50–09	1270		
					Strasbourg gives sea of Marmora near Ksara.
Sept. 11	Manila.............	3–24–24	1860	ϕ = 16° N	Batavia gives Talaud I.
1884	Strasbourg..........	3–25–42	11260	λ = 136°·5 E	
	Baku...............	3–25–50	8360	O = 3–25–21	
	Taihoku............	3–25–30	2280	Location doubtful.	
Sept. 13	Ottawa.............	14–34–23	8740	ϕ = 40° N	Ekaterinburg gives
1885	Athens.............	14–34–05	1670	λ = 43° E	ϕ = 40° 16′ N
	Barcelona..........	14–34–06	3280	O = 14–34–08	λ = 42° 30′ E.
	Belgrade...........	14–34–05	1910		
	Cartuja............	14–34–18	3680		Pulkovo gives
	Chicago............	14–34–15	9380		ϕ = 39° 54′ N
	Ekaterinburg........	14–34–13	2260		λ = 45° 04′ E.
	Georgetown.........	14–34–23	9250		
	Hamburg...........	14–33–48	2980		St. Louis gives
	Helwan............	14–34–08	1490		ϕ = 38°·5 N
	Innsbruck..........	14–33–52	2690		λ = 45° E.
	Ithaca.............	14–34–09	9050		
	Königsberg.........	14–33–58	2390		Helwan and Belgrade give
	Lemberg...........	14–34·0	1810		Erzerum.
	Osaka..............	14–34–01	8080		
	Paris..............	14–34–13	3120		
	Pulkovo............	14–33–54	2440		
	San Fernando.......	14–34–00	4140		
	Stonyhurst.........	14–34–17	3420		
	Strasbourg.........	14–33–31	3080		
	Toronto...........	14–34–17	9050		
	Uccle.............	14–34–03	3120		
	Victoria...........	14–34–49	9440		
	Wien..............	14–35–16	1640		
	Moncalieri.........	14–34–44	2340		
	Firenze............	14–34–09	2550		
	Mostar............	14–34–20	1950		
	München...........	14–34–00	2620		
	Neuchâtel..........	14–33–53	2950		
	Padova............	14–33–51	2660		
	Piacenza...........	14–34–42	2340		
	Rocca di Papa.......	14–33–10	2940		
	Tortosa............	14–34–03	3440		
	Toledo............	14–34–17	3550		
	Malaga............	14–34–20	3650		
	St. Louis..........	14–33–30	10500		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Sept. 14 1887	Ekaterinburg........	13-13-03	6800	ϕ = 50°·5 N	Ekaterinburg gives
	Pulkovo...........	13-13-04	7390	λ = 177°·5 E	ϕ = 48° 59′ N
	Uccle.............	13-13-07	8700	O = 13-13-07	λ = 175° 25′ E.
	Victoria..........	13-13-15	3840		
	Wien..............	13-12-36	9500		
	Ootomari..........	13-13-37	2300		
	Baku..............	13-13-06	8800		
Sept. 16 1888	Algiers............	2-35-49	5740	ϕ = 40°·5 N	Cartuja gives
	Cartuja...........	2-35-58	6300	λ = 71°·5 E	ϕ = 42°·7 N
	Ekaterinburg.......	2-36-10	2040	O = 2-35-51	λ = 72°·3 E.
	Helwan............	2-35-53	3580		
	Königsberg.........	2-36-06	3850		Königsberg gives highlands
	Pulkovo...........	2-35-58	3450		of Pamir.
	Uccle.............	2-36-00	5070		
	Wien..............	2-35-33	4560		
	Rocca di Papa......	2-36-02	4735		
	Padova............	2-36-04	4660		
	Tortosa...........	2-36-04	5680		
	Baku..............	2-35-37	1970		
Sept. 17 1890	Ottawa............	7-04-45	2640	ϕ = 22° N	
	Chicago...........	7-04-41	2700	λ = 70°·5 W	
	Georgetown........	7-04-39	2050	O = 7-04-28	
	Ithaca............	7-04-27	2520		
	La Paz............	7-03-20	4420		
	Toronto...........	7-04-53	2470		
Sept. 18 1892	Ekaterinburg.......	1-08-40	6020	ϕ = 35°·5 N	Ekaterinburg gives
	Pulkovo...........	1-08-40	7530	λ = 138°·5 E	ϕ = 37° 38′ N
	Zi-ka-wei.........	1-08-55	1640	O = 1-08-43	λ = 140° 43′ E.
	Kobe..............	1-08-35	545	Location approximate.	
	Mizusawa..........	1-08-46	320		
	Tyosi.............		60		
Sept. 27 1897	Hamburg...........	4-27-00	3120	ϕ = 38° N	
	Königsberg.........	4-27-33	2360	λ = 42° E	
	Innsbruck.........	4-27-29	2620	O = 4-27-27	
	Pulkovo...........	4-27-31	2380		
	Stonyhurst........	4-27-26	3550		
	Wien..............	4-27-25	2320		
	Moncalieri........	4-27-23	2720		
	Piacenza..........	4-27-33	2690		
	Baku..............	4-27-40	740		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Sept. 28	Ottawa	13-34-15	3520	ϕ = 48°·5 N	
1899	Algiers	13-34-02	2810	λ = 28° W	
	Barcelona	13-33-53	2580	O = 13-34-08	
	Cartuja	13-34-07	2360		
	Paris	13-34-12	2290		
	San Fernando	13-34-06	2250		
	Strasbourg	13-34-14	2580		
	Uccle	13-34-13	2360		
	Toledo	13-34-11	2110		
Oct. 8	Algiers	20-32-45	7850	ϕ = 32° N	Ekaterinburg gives
1903	Cartuja	20-33-06	7680	λ = 90° E	ϕ = 30° 24′ N
	Ekaterinburg	20-32-49	3470	O = 20-32-53	λ = 84° 24′ E.
	Hamburg	20-32-46	6760		
	Helwan	20-32-51	5440		
	Königsberg	20-32-46	6000		Königsberg and Toledo
	Paris	20-32-52	7320		give Tibet.
	Pulkovo	20-32-51	5280		
	Strasbourg	20-33-03	6850		
	Uccle	20-32-56	7100		Pulkovo gives
	Zi-ka-wei	20-33-03	2820		ϕ = 32°·1 N.
	Firenze	20-33-03	6720		λ = 89°·9 E.
	Tortosa	20-32-26	8080		
	Toledo	20-32-50	8280		
	Kucino	20-33-10	4740		
Oct. 10	Ekaterinburg	9-21-01	3840	ϕ = 70° N	
1904	Pulkovo	9-21-06	2450	λ = 18° W	
	Uccle	9-21-17	2470	O = 9-21-08	
Oct. 12	Algiers	19-33-53	5400	ϕ = 0°·5 S	Ekaterinburg gives
1907	Cartuja	19-34-05	4950	λ = 30°·5 W	ϕ = 3° 6′ N
	Ekaterinburg	19-34-34	9590	O = 19-34-06	λ = 27° 18′ W,
	Eskdalemuir	19-34-14	6620		Isle of St. Paul.
	Helwan	19-33-55	7700		
	La Paz	19-33-53	4740		
	Paris	19-34-00	6370		Strasbourg gives
	Pulkovo	19-34-22	8330		Atlantic ocean, region of
	San Fernando	19-33-50	4820		Isle of St. Paul.
	Strasbourg	19-34-05	6550		
	Uccle	19-34-09	6520		
	Wien	19-33-46	7280		
	Piacenza	19-34-03	6450		
	Rocca di Papa	19-33-57	6450		
	Toledo	19-34-04	5070		
	Almeria	19-34-07	4880		
	Kucino	19-34-05	8540		
	Malaga	19-34-48	4740		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 13 1909	Athens	16-17-49	3740	ϕ = 37° N	Ekaterinburg gives
	Ekaterinburg	16-17-45	2200	λ = 67°·5 E	ϕ = 37° 39′ N
	Eskdalemuir	16-17-37	5510	O = 16-17-34	λ = 67° 53′ E
	Hamburg	16-17-16	5000		
	Königsberg	16-17-41	3950		
	Pulkovo	16-17-39	3490		Pulkovo gives
	Stonyhurst	16-17-38	5450		ϕ = 37°·2 N
	Strasbourg	16-17-08	5350		λ = 64°·6 E
	Uccle	16-17-33	5150		
	Toledo	16-17-33	6180		
	Moncalieri	16-17-42	4980		
Oct. 14 1910	Ottawa	5-00-09	3530	ϕ = 22°·5 N	Königsberg gives
	Algiers	4-59-44	5000	λ = 44°·5 W	ϕ = 22° N
	Barcelona	5-00-15	4720	O = 5-00-12	λ = 47° W.
	Ekaterinburg	5-00-21	8820		
	Georgetown	4-59-56	3530		Zürich gives
	Hamburg	5-00-09	5700		ϕ = 25° N
	Königsberg	5-00-53	6080		λ = 43° W.
	La Paz	5-00-20	5020		
	Paris	5-00-10	4980		Strasbourg gives
	Porto Rico	5-00-37	1970		ϕ = 20° N
	Pulkovo	5-00-18	6990		λ = 40° W.
	Tortosa	5-00-04	4720		
	Toledo	5-00-11	4150		
	Almeria	5-00-17	4220		
	Firenze	5-00-19	5520		
	San Fernando	4-59-57	4040		
	Stonyhurst	5-00-07	4900		
	Strasbourg	5-00-12	5380		
	Toronto	5-00-00	3840		
	Uccle	5-00-09	5200		
	Wien	5-00-07	6080		
	Rocca di Papa	5-00-15	5630		
	Piacenza	4-59-50	5660		
	Padova	5-00-13	5680		
	Moncalieri	5-00-13	5320		
	Kucino	5-00-13	7630		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 18 1912	Ottawa	23-05-17	4740	ϕ = 3° N	
	Chicago	23-05-20	4400	λ = 80°·5 W	
	Eskdalemuir	23-05-39	8800	O = 23-05-26	
	Fordham	23-05-02	4370		
	Georgetown	23-05-22	3800		
	Hamburg	23-05-37	9580		
	La Paz	23-05-12	2590		
	Porto Rico	23-05-22	2330		
	Rio de Janeiro	23-05-17	4780		
	San Fernando	23-05-40	8500		
	Stonyhurst	23-05-28	9020		
	Strasbourg	23-06-27	9740		
	Toronto	23-05-30	4370		
	Uccle	23-05-40	9200		
	Toledo	23-05-40	8450		
	Malaga	23-05-30	8600		
Oct. 19 1914	Algiers	23-52-20	4350	ϕ = 26° N	
	Cartuja	23-51-46	4080	λ = 43° W.	
	Pulkovo	23-52-17	6600	O = 23-51-58	
	San Fernando	23-52-02	3600		
	Strasbourg	23-51-58	4980		
	Toledo	23-51-59	4000		
	Almeria	23-51-47	4020		
	Malaga	23-51-36	4010		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 20 1917	Ottawa	19-52-56	7320	ϕ = 56° N	Ekaterinburg gives
	Algiers	19-52-30	9740	λ = 166° E	ϕ = 53·8 N
	Athens	19-52-44	9100	O = 19-52-46	λ = 164°·9 E
	Barcelona	19-52-56	9040		
	Cartuja	19-52-48	9650		Königsberg gives
	Chicago	19-53-17	6950		ϕ = 53° N
	Ekaterinburg	19-52-41	5800		λ = 165° E.
	Eskdalemuir	19-52-49	7680		
	Georgetown	19-52-47	7960		Zürich gives
	Hamburg	19-53-01	7460		ϕ = 57° N
	Königsberg	19-52-52	7340		λ = 170° E.
	Osaka	19-52-35	3180		
	Paris	19-52-53	8300		St. Louis gives
	Pulkovo	19-52-42	6620		ϕ = 55° N
	San Fernando	19-53-34	9120		λ = 166° E.
	Strasbourg	19-52-41	8380		
	Uccle	19-52-44	8150		
	Victoria	19-52-31	4740		
	Wien	19-52-44	8250		
	Zi-ka-wei	19-52-42	4100		
	Mizusawa	19-52-45	2510		
	Piacenza	19-52-43	8800		
	Rocca di Papa	19-52-46	8940		
	Padova	19-52-48	8600		
	Moncalieri	19-53-37	8550		
	St. Louis	19-53-33	6960		
	Sitka	19-52-45	3360		
	Honolulu	19-53-58	4200		
	Tortosa	19-52-44	9280		
	Malaga	19-53-04	9800		
	Toledo	19-52-55	9220		
	Almeria	19-52-48	9450		
	Firenze	19-52-07	9200		
	Tyosi	19-52-55	2590		
Oct. 27 1920	Batavia	19-56-52	2540	ϕ = 8° N	Ekaterinburg gives
	Ekaterinburg	19-57-11	7770	λ = 126° E	ϕ = 6° 1′ N
	Manila	19-56-42	1200	O = 19-57-09	λ = 122° 31′ E.
	Osaka	19-57-34	3000	Location approximate.	
	Pulkovo	19-57-16	9400		
	Zi-ka-wei	19-56-58	2690		
	Jinsen	19-57-06	2820		
	Mizusawa	19-57-22	3680		
	Moncalieri	19-57-00	12150		
	Kucino	19-57-25	8950		
Nov. 1 1922	Ottawa	4-55-21	4180	ϕ = 9° N	
	Chicago	4-55-13	3690	λ = 86° W	
	Porto Rico	4-55-43	2470	O = 4-55-26	
	Toronto	4-55-26	3810		

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 20	Algiers	20–26–41	2760	ϕ = 38° N	Irkutsk gives
1928	Athens	20–27–52	650	λ = 30°·8 E	ϕ = 41°·3 N
	Belgrade	20–28–01	950	O = 20–27–33	λ = 26°·6 E.
	Cartuja	20–27–12	3200		
	Hamburg	20–27–35	2350		Pulkovo gives
	Helwan	20–28–03	830		ϕ = 32°·2 N
	Königsberg	20–27–35	2020		λ = 30°·3 E.
	Paris	20–27–37	2510		
	Pulkovo	20–27–38	2360		Strasbourg, Wien and
	Stonyhurst	20–27–35	2970		Königsberg give region of
	Strasbourg	20–27–36	2210		Afium Karahissar, Asia
	Uccle	20–27–34	2500		Minor.
	Wien	20–27–37	1620		
	Zürich	20–27–34	2100		
	Chur	20–27–36	2030		
	München	20–27–35	1950		
	Piacenza	20–27–22	2080		
	Toledo	20–27–26	3040		
	Almeria	20–27–04	3140		
	Malaga	20–27–13	3240		
	Firenze	20–27–41	1800		
	Moncalieri	20–27–40	1950		
	Baku	20–27–40	1710		
	Irkutsk	20–27–31	5750		
Dec. 9	Ekaterinburg	11–54–25	8820	ϕ = 1° S	
1933	Osaka	11–55–08	3250	λ = 130° E	
	Perth	11–54–20	3420	O = 11–54·3	
	Irkutsk	11–53–09	7220	Location only roughly approximate.	
Dec. 13	Ekaterinburg	23–45–21	8760	ϕ = 14° S	Baku gives
1937	Baku	23–45–08	8360	λ = 107° E	ϕ = 51° 31′ N
	Irkutsk	23–44–04	7530	O = 23–44–50	λ = 171° 51′ E.
				Location doubtful	
Dec. 27	Ottawa	11–22–10	8900	ϕ = 46° N	Ekaterinburg gives
1944	Athens	11–22–09	9000	λ = 144° E	ϕ = 50° 27′ N
	Cartuja	11–22–24	9850	O = 11–22–13	λ = 149° 54′ E.
	Chicago	11–21–57	8800		
	Ekaterinburg	11–22–05	5500		Pulkovo gives
	Georgetown	11–22–35	8880		ϕ = 50° 30′ N
	Hamburg	11–22–10	8100		λ = 156°20′E
	Innsbruck	11–22–12	8600		
	Königsberg	11–22–05	7620		Zurich gives
	Osaka	11–23–02	940		ϕ = 48° N
	Paris	11–22–11	8750		λ = 148° E.
	Pulkovo	11–22–01	6830		
	Toronto	11–22–02	9000		Irkutsk gives
	Uccle	11–22–12	8500		ϕ = 45°·2 N
	Wien	11–22–06	8400		λ = 143°·2 E

LOCATION OF EPICENTRES, 1924

Date	Station	O	Δ	Epicentre	Other Locations
Dec. 27 1944	Zi-ka-wei	11–22–04	2400		Baku gives
	Zürich	11–22–08	8720		ϕ = 55° 59′ N
	Irkutsk	11–23–14	2160		λ = 153° 22′ E.
	München	11–22–14	8500		
	Naples	11–22–11	8900		
	Rocca di Papa	11–22–12	9000		
	Toledo	11–22–09	9740		
	Almeria	11–22–04	9600		
	Malaga	11–22–18	9820		
	Ootomari	11–22–13	325		
	Kobe	11–21–21	1690		
	Mizusawa	11–22–18	550		
	Moncalieri	11–22–35	8840		
	Kucino	11–22–05	6750		
	Baku	11–22–16	7120		
Dec. 28 1945	Ottawa	22–54–57	9250	ϕ = 43° N	Ekaterinburg gives
	Belgrade	22–54–45	9280	λ = 147° E	ϕ = 48° 49′ N
	Cartuja	22–54–42	10880	O = 22–54–52	λ = 153° 40′ E.
	Ekaterinburg	22–55–00	5820		
	Fordham	22–55–26	9300		Irkutsk gives
	Hamburg	22–55–05	8480		ϕ = 46°·6 N
	Honolulu	22–54–18	5930		λ = 147°·0 E.
	Innsbruck	22–55–08	8950		
	Königsberg	22–54–52	8200		Zürich gives
	La Paz	22–54–42	16470		ϕ = 43° N
	Lemberg	22–55·1	8200		λ = 145° E.
	Naples	22–55–09	9200		
	Osaka	22–54–09	1800		St. Louis gives
	Perth	22–55–00	8920		ϕ = 44° N
	Toronto	22–54–34	9500		λ = 150° E.
	Uccle	22–55–00	9000		
	Wien	22–54–46	9060		
	Zi-ka-wei	22–55–02	2600		
	Irkutsk	22–54–39	3290		
	Zürich	22–55–04	9060		
	Firenze	22–54–11	9940		
	Sitka	22–54–43	5600		
	St. Louis	22–55–21	8980		
	München	22–54–57	9160		
	Rocca di Papa	22–54–58	9550		
	Malaga	22–53–38	11020		
	Almeria	22–54–59	9940		
	Toledo	22–55–05	10120		
	Taihoku	22–54–45	3150		
	Moncalieri	22–55–20	9580		
	Baku	22–55–03	7580		
	Mizusawa	22–55–17	560		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Jan. 5	Ottawa	13-45-35	6480	ϕ = 13° S	
1950	Cartuja	13-45-50	8880	λ = 71° W	
	Chicago	13-46-14	6180	O = 13-45-41	
	Georgetown	13-44-54	6150		
	La Paz	13-45-48	530		
	Toronto	13-45-40	6250		
	La Plata	13-45·8	2510		
Jan. 18	Ottawa	12-06-08	8400	ϕ = 49° N	Strasbourg gives
1957	Algiers	12-06-31	9330	λ = 154° E	ϕ = 48° N
	Athens	12-06-06	9050	O = 12-06-02	λ = 155° E.
	Barcelona	12-06-20	9220		
	Batavia	12-06-00	7450		Uccle gives
	Belgrade	12-06-06	8620		ϕ = 48° N
	Cartuja	12-06-17	9440		λ = 150°·5 E.
	Cheltenham	12-06-06	9010		
	Eskdalemuir	12-06-01	8270		Zürich gives
	Fordham	12-06-04	8980		ϕ = 49° N
	Georgetown	12-06-04	9000		λ = 155° E.
	Hamburg	12-06-02	8160		
	Helwan	12-06-22	9120		Baku gives
	Honolulu	12-05-23	5420		ϕ = 55° 56′ N
	Innsbruck	12-05-56	8780		λ = 171° 44′ E.
	Ithaca	12-06-54	8400		
	Königsberg	12-06-02	7720		Irkutsk gives
	Manila	12-04-24	5760		ϕ = 50°·1 N
	Osaka	12-06-11	2000		λ = 153°·3 E.
	Paris	12-05-59	8820		
	Pulkovo	12-05-53	6960		Apia gives
	Strasbourg	12-06-04	8680		ϕ = 48° N
	Sydney	12-06-05	8850		λ = 160° W.
	Tokio	12-06-02	1690		
	Toronto	12-06-13	8360		Toledo gives
	Tucson	12-06-07	7720		ϕ = 49° N
	Uccle	12-06-00	8580		λ = 155° E.
	Victoria	12-05-46	5810		
	Wien	12-05-57	8550		
	Zi-ka-wei	12-05-52	3140		
	Zürich	12-06-02	8800		
	München	12-06-05	8620		
	Tyosi	12-04-12	1960		
	Bergen	12-06-27	7420		
	Rocca di Papa	12-06-10	9060		
	Baku	12-05-53	7730		
	Naples	12-06-17	9200		
	Irkutsk	12-05-44	3360		
	Aachen	12-06-12	8450		
	Nagasaki	12-06-09	2380		
	Spring Hill	12-06-09	9100		
	Sitka	12-06-19	4370		
	Apia	12-06-25	7390		
	Toledo	12-06-16	9420		
	Jinsen	12-05-55	2400		
	New Orleans	12-06-09	9100		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Jan. 26	Ottawa	19-02-05	4140	ϕ = 8°·5 N	
1961	Chicago	19-02-19	3740	λ = 79°·5 W	
	Fordham	19-02-14	3550	O = 19-02·2	
	Georgetown	19-02-09	3360	Location approximate.	
	Ithaca	19-02-44	3280		
	San Fernando	19-02-18	8600		
	Tucson	19-01-50	4150		
	Victoria	19-01-41	6270		
	Toledo	19-02-17	8550		
	Malaga	19-02-17	8550		
	New Orleans	19-02-19	2440		
	La Plata	19-02·1	5550		
Jan. 28	Ottawa	4-06-00	8940	ϕ = 43° N	Pulkovo gives
1962	Algiers	4-06-16	9400	λ = 147° E	ϕ = 45°·9 N
	Athens	4-06-15	8880	O = 4-05-44	λ = 153°·5 E.
	Kucino	4-05-34	7100		
	Batavia	4-05-41	6750		Tokio gives
	Ekaterinburg	4-05-33	5780		ϕ = 42° N
	Eskdalemuir	4-05-34	8700		λ = 146°·2 E.
	Hamburg	4-05-33	8550		
	Helwan	4-05-45	9340		Zürich gives
	Innsbruck	4-06-00	8720		ϕ = 45° N
	Königsberg	4-05-39	7980		λ = 150° E.
	Osaka	4-05-47	1380		
	Paris	4-05-49	9020		Baku gives
	Pulkovo	4-05-38	7080		ϕ = 46° 55′ N
	Strasbourg	4-05-37	9070		λ = 158° 12′ E.
	Sydney	4-05-31	8570		
	Tokio	4-05-56	900		
	Toronto	4-05-41	9150		
	Uccle	4-05-35	8950		
	Victoria	4-05-44	6350		
	Wien	4-05-32	8840		
	Zi-ka-wei	4-05-34	2590		
	Zürich	4-05-41	9050		
	Tyosi	4-05-42	950		
	Firenze	4-05-42	9200		
	München	4-05-34	8950		
	Baku	4-05-17	8000		
	Neuchâtel	4-05-54	9020		
	Piacenza	4-05-56	9080		
	Rocca di Papa	4-05-49	9200		
	Jinsen	4-05-59	1600		
	Kobe	4-05-38	1400		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Jan. 28	Chicago	10-57-32	4060	ϕ = 8°·5 N	
1963	Ottawa	10-58-27	4060	λ = 79°·5 W	
	La Paz	10-58-50	3050	O = 10-58·4	
	Toronto	10-58-25	3810	Location and O approximate.	
Jan. 30	Ekaterinburg	17-28-16	6370	ϕ = 53° N	
1967	Pulkovo	17-28-20	7080	λ = 172°·5 E	
	Victoria	17-28-21	4260	O = 17-28-23	
	Toledo	17-28-34	9420		
	Irkutsk	17-28-20	4260		
	Kucino	17-28-25	7240		
Jan. 31	Ekaterinburg	17-00-30	6080	ϕ = 45° N	
1968	Zi-ka-wei	17-00-13	2890	λ = 151° E	
	Baku	17-00-37	7780	O = 17-00-28	
	Irkutsk	17-00-31	3290	Location approximate.	
Feb. 1	Ottawa	(5-24-29)	8860	ϕ = 45° N	Ekaterinburg gives
1969	Algiers	5-24-49	9280	λ = 150° E	ϕ = 47° 46′ N
	Athens	5-24-05	9230	O = 5-23-58	λ = 150° 51′ E.
	Belgrade	5-24-13	8670		
	Berkeley	5-22-38	8000		Strasbourg gives
	Cartuja	5-24-10	9940		ϕ = 47° N
	Ekaterinburg	5-24-03	5760		λ = 152° E.
	Hamburg	5-24-04	8500		
	Königsberg	5-23-05	7960		Zürich gives
	Osaka	5-24-18	1550		ϕ = 45° N
	Paris	5-23-31	9450		λ = 150° E.
	Pulkovo	5-24-04	7110		
	Strasbourg	5-24-13	8920		
	Sydney	5-23-53	8670		
	Uccle	5-24-04	8880		
	Wien	5-23-47	9080		
	Zi-ka-wei	5-23-35	2280		
	Zürich	5-24-08	9020		
	München	5-23-41	9320		
	Rocca di Papa	5-24-29	8940		
	Toledo	5-23-57	10250		
	Almeria	5-24-13	10480		
	Malaga	5-24-14	10260		
	Jinsen	5-23-39	2020		
	Kobe	5-24-05	1510		
	Baku	5-23-57	7680		
Feb. 2	Osaka	11-40-11	1400	ϕ = 45° N	
1972	Jinsen	11-39-00	1770	λ = 145° E	
	Irkutsk	11-39-25	2990	O = 11-39·5	
				Location doubtful.	

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Feb. 2	Ottawa	(13–29–28)	8940	ϕ = 45° N	Irkutsk gives
1973	Ekaterinburg	13–29–06	5910	λ = 149°·5 E	ϕ = 43°·5 N
	Eskdalemuir	13–29–46	8440	O = 13–29–08	λ = 147 ·1 E
	Hamburg	13–29–06	8720		
	Helwan	13–29–30	9300		
	Kobe	13–29–02	1510		
	Kucino	13–29–26	6950		
	Irkutsk	13–28–54	3300		
	Jinsen	13–29–00	2000		
	Manila	13–29–04	4380		
	Malaga	13–28–49	10400		
	München	13–28–26	9550		
	Osaka	13–29–18	1580		
	Pulkovo	13–29–11	7240		
	Strasbourg	13–29–16	9010		
	Uccle	13–29–21	8840		
	Wien	13–29–05	9010		
	Zi-ka-wei	13–28–54	2770		
Feb. 2	Ottawa	19–46–47	9230	ϕ = 44° N	Pulkovo gives
1974	Algiers	19–47–27	9580	λ = 149° E	ϕ = 40°·9 N
	Athens	19–46–56	9200	O = 19–46–50	λ = 141°·3 E.
	Batavia	19–46–49	6820		
	Belgrade	19–46–47	9060		
	Berkeley	19–46–47	7250		Zürich gives
	Cartuja	19–46–55	10060		ϕ = 45° N
	Chicago	19–46–08	9660		λ = 150° E.
	Georgetown	19–47–00	9650		
	Hamburg	19–46–56	8500		
	Helwan	19–47–04	9350		
	Innsbruck	19–47–08	8800		
	Königsberg	19–47–32	7350		
	Lick	19–47–01	7220		
	Manila	19–46–21	4360		
	Osaka	19–47–28	1390		
	Paris	19–46–54	9160		
	Pulkovo	19–46–51	7180		
	Strasbourg	19–46–54	9060		
	Toronto	19–46–58	9080		
	Uccle	19–46–53	8950		
	Wien	19–46–51	8840		
	Zi-ka-wei	19–45–42	2660		
	Zürich	19–46–59	9040		
	Firenze	19–46–53	9340		
	München	19–46–48	9120		
	Toledo	19–46–56	10150		
	Jinsen	19–46–32	2010		
	Irkutsk	19–46–29	3400		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Feb. 7 1980	Athens	12-14-40	450	ϕ = 36°·5 N	
	Belgrade	12-14-40	990	λ = 31°·2 E	
	Ekaterinburg	12-14-53	3490	O = 12-14-50	
	Königsberg	12-14-57	1980		
	Pulkovo	12-15-00	2530		
	Strasbourg	12-14-44	1760		
	Uccle	12-15-08	1930		
Feb. 7 1981	Ekaterinburg	18-18-03	6060	ϕ = 25° N	
	Osaka	18-18-16	2350	λ = 114° E	
	Zi-ka-wei	18-17-59	780	O = 18-18-11	
	Irkutsk	18-18-25	3180		
Feb. 16 1992	Ottawa	17-47-36	8420	ϕ = 46° N	
	Chicago	17-47-24	8580	λ = 160° E	
	Toronto	17-47-42	8300	O = 17-47-24	
	Baku	17-46-54	8150	Location doubtful.	
Feb. 20 1993	Ottawa	1-02-28	8840	ϕ = 46° N	Pulkovo gives
	Belgrade	1-02-39	8670	λ = 149°·8 E	ϕ = 48°·9 N
	Cartuja	1-02-38	9850	O = 1-02-29	λ = 156°·7 E
	Chicago	1-02-49	8520		
	Ekaterinburg	1-02-21	5800		Baku gives
	Eskdalemuir	1-02-27	8520		ϕ = 53° 9′ N
	Firenze	1-02-37	9000		λ = 159° E.
	Georgetown	1-02-56	8980		
	Hamburg	1-02-27	8320		
	Helwan	1-02-47	9160		
	Königsberg	1-02-31	7860		
	Kucino	1-02-18	7180		
	Lemberg	1-02·4	8200		
	Malaga	1-02-15	10050		
	Osaka	1-02-32	1650		
	Paris	1-02-33	8950		
	Piatigorsk	1-02-20	7820		
	Pulkovo	1-02-28	7000		
	San Fernando	1-02-13	10450		
	Strasbourg	1-02-29	8870		
	Toronto	1-02-35	8800		
	Uccle	1-02-29	8740		
	Victoria	1-02-16	6220		
	Wien	1-02-23	8740		
	Zi-ka-wei	1-02-16	2840		
	Zürich	1-02-29	9010		
	Baku	1-02-29	7600		
	Irkutsk	1-02-21	3270		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Feb. 23 1996	Ottawa	23-53-38	4700	ϕ = 60°·8 N.	Zürich gives
	Algiers	23-53-52	8780	λ = 146°·7 W	ϕ = 60° N
	Athens	23-53-52	8900	O = 23-53-43	λ = 150° W
	Belgrade	23-53-57	8160		
	Berkeley	23-53-34	3070		Ekaterinburg gives
	Almeria	23-53-45	8720		ϕ = 65° 12′ N
	Cartuja	23-53-36	8880		λ = 134° 7′ W
	Cheltenham	23-53-39	5240		
	Chicago	23-53-31	4420		Press reports quake felt at
	Ekaterinburg	23-54-00	6390		Seward and Anchorage,
	Fordham	23-53-35	5250		Alaska. Two distinct
	Firenze	23-53-32	8550		tremors, the second more
	Hamburg	23-53-42	7200		severe. Chimneys were
	Helwan	23-54-17	9500		wrecked and water pipes
	Honolulu	23-53-18	4660		broken at Seward.
	Halifax	23-53-46	5360		
	Innsbruck	23-53-51	7800		
	Ithaca	23-53-25	4960		
	Jinsen	23-53-24	6330		
	Königsberg	23-53-50	7050		
	Kucino	23-53-49	7000		
	Lick	23-53-27	3190		
	Malaga	23-53-42	8720		
	New Orleans	23-53-45	5100		
	Pulkovo	23-53-41	6600		
	Piatigorsk	23-54-01	8300		
	San Fernando	23-53-47	8680		
	Strasbourg	23-53-38	7800		
	Spring Hill	23-53-59	5280		
	Sitka	23-53-30	880		
	Toronto	23-53-32	4720		
	Tucson	23-53-37	4080		
	Toledo	23-53-43	8400		
	Uccle	23-53-43	7400		
	Victoria	23-53-39	2180		
	Wien	23-54-17	7200		
	Zi-ka-wei	23-53-44	7080		
	Zürich	23-53-52	7780		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Mar. 1 1999	Ottawa..........	2-19-20	480	ϕ = 47°·6 N	Ekaterinburg gives
	Algiers..........	2-19-07	5900	λ = 70°·1 W	ϕ = 47° 26′ N
	Barcelona..........	2-18-40	5750	O = 2-19-20	λ = 71° 26′ W.
	Berkeley..........	2-19-06	4250		
	Cartuja..........	2-19-10	5440	Felt throughout	Strasbourg gives
	Cheltenham..........	2-19-31	1050	Eastern Canada and	ϕ = 48° N
	Chicago..........	2-19-44	1300	United States.	λ = 68° W.
	Coimbra..........	2-19-08	4820		
	Ekaterinburg..........	2-19-18	7610		Zürich gives
	Eskdalemuir..........	2-19-27	4140		ϕ = 48° N
	Fordham..........	2-19-27	710		λ = 70° W.
	Georgetown..........	2-19-29	1040		
	Hamburg..........	2-19-18	5240		
	Helwan..........	2-19-19	8420		
	Königsberg..........	2-19-09	5990		
	La Paz..........	2-19-21	7000		
	Paris..........	2-19-10	5120		
	Pulkovo..........	2-19-11	6110		
	Rio de Janeiro..........	2-19-20	8280		
	Strasbourg..........	2-19-11	5500		
	Toronto..........	2-19-25	760		
	Uccle..........	2-19-13	5070		
	Victoria..........	2-19-00	3870		
	Wien..........	2-19-11	6050		
	Zürich..........	2-19-08	5650		
	Spring Hill..........	2-19-24	2410		
	Halifax..........	2-19-28	590		
	Saskatoon..........	2-19-12	2610		
	Piatigorsk..........	2-19-25	8000		
	St. Louis..........	2-19-32	1750		
	Baku..........	2-19-09	8800		
	Toledo..........	2-19-14	5070		
	Almeria..........	2-19-10	5450		
	Malaga..........	2-19-05	5400		
	Alicante..........	2-18-55	5700		
	Firenze..........	2-18-58	6220		
	Agram..........	2-19-19	6180		
	La Plata..........	2-19·6	9020		
Mar. 1 2003	Ekaterinburg..........	12-25-28	6110	ϕ = 28° N	
	Pulkovo..........	12-25-41	7790	λ = 128° E	
	Baku..........	12-25-20	7120	O = 12-25-32	
	Irkutsk..........	12-25-41	3280		
Mar. 15 2015	Ekaterinburg..........	15-41-40	8980	ϕ = 9° S	Irkutsk gives
	Baku..........	15-41-43	8940	λ = 119° E	ϕ = 7°·7 S
	Irkutsk..........	15-41-36	6960	O = 15-41-40	λ = 125°·6 E.

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Mar. 16	Cartuja..........	14–42–15	9480	ϕ = 26° N	Ekaterinburg gives
2017	Ekaterinburg.......	14–42–09	4600	λ = 100° E	ϕ = 24° 16′ N
	Eskdalemuir.......	14–42–44	8050	O = 14–42–13	λ = 96° 4′ E.
	Helwan............	14–42–02	6860		
	Innsbruck..........	14–42–39	7600		Pulkovo gives
	Königsberg.......	14–41–48	7720		ϕ = 22° 51′ N
	Manila............	14–42–42	2190		λ = 96° 27′ E.
	Paris.............	14–42–28	8380		
	Pulkovo...........	14–42–07	6500		Strasbourg and Toledo give
	Strasbourg........	14–41–37	8500		ϕ = 26° N
	Uccle.............	14–42·3	8250		λ = 100° E.
	Wien..............	14–41–59	7720		
	Zi-ka-wei.........	14–42–04	2190		
	Zürich............	14–42–23	8000		Wien and Zürich give
	Taihoku...........	14–42–09	2200		ϕ = 27° N
	Irkutsk...........	14–42–02	2950		λ = 100° E.
	Toledo............	14–42–23	9230		
	Almeria...........	14–42–20	9440		Irkutsk gives
	Malaga............	14–42–29	9150		ϕ = 26°·2 N
	Nagasaki..........	14–41–38	3270		λ = 96° 52′ E.
	Firenze...........	14–41–58	8200		
	Agram.............	14–42–20	7560		Zi-ka-wei, Manila and
	Piatigorsk........	14–42–34	5380		Taihoku give
					Yunnan, China.
Mar. 22	Ekaterinburg.......	8–41–56	12360	ϕ = 17° S	Ekaterinburg gives
2028	Honolulu..........	8–41–34	5980	λ = 168° E	ϕ = 15° 29′ S
	Manila............	8–42–03	6250	O = 8–41–53	λ = 161° 4′ E.
	Melbourne.........	8–41·5	3330		
	Osaka.............	8–41–53	6850		Apia gives
	Perth.............	8–42–15	5120		ϕ = 18° S
	Victoria..........	8–41–52	9930		λ = 170° E.
Mar. 26	Batavia...........	10–25–02	2350	ϕ = 7° N	Manila gives Pacific SE. of
2034	Ekaterinburg.......	10–25–18	7650	λ = 123° E	Mindanao.
	Manila............	10–24–40	1430	O = 10–25–08	
	Osaka.............	10–25–16	4100		
	Pulkovo...........	10–25–21	9200		
	Zi-ka-wei.........	10–24–57	2780		
	Baku..............	10–25–22	8070		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Mar. 29 2039	Ottawa............	21-12-32	3980	ϕ = 9° N	Fordham, La Paz, New Orleans and La Plata give Panama.
	Algiers............	21-12-36	8650	λ = 79°·5 W	
	Berkeley............	21-12-29	5550	O = 21-12-27	
	Cartuja............	21-11-53	8750		
	Cheltenham............	21-12-41	3120		
	Chicago............	21-12-14	3830		Lick gives
	Eskdalemuir............	21-12-42	8250		ϕ = 5° S
	Fordham............	21-12-12	3690		λ = 105° W.
	Georgetown............	21-12-32	3280		
	Ithaca............	21-12-32	3660		Pulkovo gives
	La Paz............	21-12-35	2810		ϕ = 17°·2 N
	Lick............	21-12-31	5450		λ = 80° W.
	Paris............	21-12-17	8900		
	San Fernando............	21-11-55	8650		Zürich gives
	Strasbourg............	21-12-37	9000		ϕ = 5° N
	Toronto............	21-12-32	3780		λ = 72° W.
	Tucson............	21-12-35	4220		
	Uccle............	21-12-34	8780		
	Victoria............	21-12-26	6220		
	Zürich............	21-12-33	9100		
	New Orleans............	21-12-30	9100		
	Toledo............	21-12-35	8070		
	Almeria............	21-12-36	8250		
	Malaga............	21-12-30	8120		
	Alicante............	21-11-57	8120		
	Agram............	21-12-25	9860		
	La Plata............	21-12·5	5100		
April 5 2042	Athens............	3-04-27	480	ϕ = 35° N	
	Belgrade............	3-04-33	1560	λ = 28° E	
	Pulkovo............	3-04-32	2580	O = 3-04-30	
	Uccle............	3-04-25	2590	Location approximate.	
	Wien............	3-04-45	1610		
	Toledo............	3-04-12	3040		
	Agram............	3-04-33	1650		
	Piatigorsk............	3-04-41	1500		
	Kucino............	3-04-27	2200		
April 7 2044	Batavia............	18-05-49	2520	ϕ = 8° N	Ekaterinburg gives
	Ekaterinburg............	18-05-39	7850	λ = 127° E............	ϕ = 11° 7′ N
	Königsberg............	18-05-43	10120	O = 18-05-41	λ = 127° 43′ E.
	Manila............	18-05-47	950		
	Perth............	18-05-37	4340		Manila gives E. coast of Mindanao I.
	Pulkovo............	18-05-41	9500		
	Irkutsk............	18-05-32	5300		
	Baku............	18-05-38	8450		
	Piatigorsk............	18-05-43	8850		Irkutsk gives ϕ = 8° N λ = 123°·6 E.

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
April 11	Algiers	10-42-20	9420	ϕ = 34° S	Strasbourg gives
2045	Athens	10-42-02	8720	λ = 59° E	ϕ = 33° S
	Barcelona	10-42-08	10170	O = 10-42-08	λ = 60° E
	Batavia	10-42-03	5840	Location approximate.	
	Harvard	10-41-56	15900		Zürich gives
	Melbourne	10-42·5	7800		ϕ = 30° S
	Paris	10-42-01	10700		λ = 50° E.
	Rio de Janeiro	10-42-20	9400		
	San Fernando	10-42-19	10150		
	Strasbourg	10-41-54	10550		
	Almeria	10-42-05	10100		
	Malaga	10-41-51	10350		
	Alicante	10-42-01	10180		
	Firenze	10-42-28	9440		
	La Plata	10-42-04	9400		
	Piatigorsk	10-41-50	8980		
April 16	Batavia	19-52-27	3410	ϕ = 22°·5 N	Ekaterinburg gives
2046	Belgrade	19-52-54	8920	λ = 122° E	ϕ = 22° 51′ N
	Chicago	19-53	12000	O = 19-52-37	λ = 122° 10′ E.
	Ekaterinburg	19-51-36	6190		
	Hamburg	19-52-53	9160		Pulkovo gives
	Honolulu	19-52-50	8180		ϕ = 23° 15′ N
	Innsbruck	19-52-56	9350		λ = 122° 18′ E.
	Königsberg	19-52-48	8620		
	Lemberg	19-52·6	8680		Baku gives
	Manila	19-51-43	1230		ϕ = 35°·7 N.
	Osaka	19-52-46	1950		λ = 132°·9 E.
	Perth	19-52-30	5980		
	Pulkovo	19-52-44	7900		Zürich gives.
	Baku	19-52-36	7000		ϕ = 25° N
	Strasbourg	19-52-47	9660		λ = 115° E.
	Uccle	19-53-05	9320		
	Wien	19-52-43	9220		
	Zürich	19-52-49	9600		Irkutsk gives
	Nagasaki	19-52-54	1335		ϕ = 26°·8 N
	Taihoku	19-52-33	440		λ = 129°·8 E.
	Firenze	19-52-44	9740		
	Jinsen	19-52-39	1800		
	Agram	19-52-20	9600		
	Irkutsk	19-52-30	3530		
	Kobe	19-52-34	2035		
	Sumoto	19-52-18	2035		
	Bergen	19-52-32	9300		
	Piatigorsk	19-52-36	7460		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
April 19 2047	Batavia	15-46-34	4860	ϕ = 37° N	Ekaterinburg gives
	Ekaterinburg	15-45-34	5720	λ = 135° E	ϕ = 37° 42′ N
	Pulkovo	15-46-36	7220	O = 15-46-32	λ = 135° 41′ E.
	Nagasaki	15-46-44	620	Location approximate.	
	Jinsen	15-46-43	1050		Kobe gives near
	Kobe	15-46-48	360		Noto peninsula, Japan.
	Sumoto	15-46-43	360		
	Irkutsk	15-46-31	2970		
	Baku	15-46-38	7050		
April 19 2048	Ekaterinburg	20-40-38	6170	ϕ = 38° N	Sumoto gives
	Osaka	20-42-12	700	λ = 142° E	E. of Kinkwazan I.
	Pulkovo	20-41-54	7390	O = 20-42-02	
	Sumoto	20-42-00	800	Location approximate.	
	Irkutsk	20-42-03	3000		
April 22 2049	Batavia	23-10-30	2540	ϕ = 0°·5S	
	Ekaterinburg	23-10-52	8680	λ = 129°·5 E	
	Manila	23-10-34	1950	O = 23-10-36	
	Baku	23-10-45	9130		
	Piatigorsk	23-10-18	9680		
May 3 2059	Honolulu	17-22-08	8260	ϕ = 3°·5 N	Ekaterinburg gives
	Zi-ka-wei	17-21-48	3130	λ = 127° E	ϕ = 1° 40′ N
	Manila	17-22-31	1220	O = 17-21-52	λ = 123° 39′ E.
	Irkutsk	17-21-45	590		
	Batavia	17-21-31	2450		Pulkovo gives
	Ekaterinburg	17-21-59	8250		ϕ = 3° 37′ N
	Pulkovo	17-21-51	9980		λ = 126° E.
	Athens	17-21-05	10560		
	Königsberg	17-22-13	10250		
	Agram	17-21-57	11020		Irkutsk gives
	Strasbourg	17-21-54	11460		ϕ = 3°·4 N
	Paris	17-21-52	11820		λ = 132° 1 E.
	Baku	17-21-55	8700		
	Uccle	17-21-43	11700		
	Jinsen	17-21-54	3690		
	Kobe	17-21-42	3600		
	Piatigorsk	17-21-53	9200		
	Kucino	17-21-56	9440		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
May 3 2060	Algiers	22-59-25	9320	$\phi = 34°$ S	Ekaterinburg gives
	Athens	22-59-02	8750	$\lambda = 56°$ E	$\phi = 22°\ 13'$ S
	Barcelona	22-59-06	10100	O = 22-59-07	$\lambda = 96°\ 58'$ E.
	Helwan	22-59-08	7620	Location approximate.	
	Perth	22-58-45	5580		Strasbourg gives
	Strasbourg	22-59-01	10380		$\phi = 34°$ S
	Wien	22-59-03	9940		$\lambda = 55°$ E.
	Zi-ka-wei	22-59-15	9550		
	Zürich	22-59-03	10220		
	Almeria	22-59-19	9860		
	Alicante	22-59-09	10000		
	Piatigorsk	22-59-06	8920		
	Baku	22-59-10	8360		
May 5 2062	Batavia	10-06-02	2540	$\phi = 9°$ N	Ekaterinburg gives
	Belgrade	10-07-12	10150	$\lambda = 123°{\cdot}5$ E	$\phi = 5°\ 16'$ N
	Ekaterinburg	10-06-12	7470	O = 10-06-09	$\lambda = 115°\ 47'$ E.
	Helwan	10-06-10	9620		
	Honolulu	10-06-26	8440		Pulkovo gives
	Königsberg	10-06-25	9620		$\phi = 6°{\cdot}8$ N
	Manila	10-06-03	600		$\lambda = 120°{\cdot}3$ E.
	Osaka	10-06-02	3100		
	Pulkovo	10-06-16	9130		Manila gives Negros I.
	Strasbourg	10-06-01	10950		
	Zi-ka-wei	10-05-53	2480		
	Taihoku	10-06-33	1560		
	Jinsen	10-06-01	2930		
	Kobe	10-05-50	3100		
	Baku	10-06-16	7900		
	Piatigorsk	10-06-01	8620		
May 5 2064	Batavia	23-21-08	2260	$\phi = 2°{\cdot}5$ N	Ekaterinburg gives
	Ekaterinburg	23-21-17	8290	$\lambda = 126°{\cdot}2$ E	$\phi = 0°\ 24'$ N
	Honolulu	23-21-21	8400	O = 23-21-12	$\lambda = 121°\ 23'$ E.
	Paris	23-21-16	11800		
	Perth	23-21-09	3630		
	Pulkovo	23-21-10	10000		
	Zi-ka-wei	23-20-59	3230		
	Baku	23-21-16	8680		
	Piatigorsk	23-21-12	9230		
May 13 2074	Algiers	23-54-42	9100	$\phi = 10°$ N	Ekaterinburg gives
	Ekaterinburg	23-54-38	5630	$\lambda = 91°$ E	$\phi = 11°\ 46'$ N
	Pulkovo	23-54-33	7430	O = 23-54-30	$\lambda = 90°\ 41'$ E.
	Uccle	23-54·0	9280	Location approximate.	
	Wien	23-54-36	8100		
	Baku	23-54-15	5560		
	Almeria	23-54-52	9400		
	Malaga	23-54-33	9850		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
May 15 2075	Ottawa..........	11-57-07	7800	ϕ = 24° S	
	Fordham..........	11-57-05	7300	λ = 67° W	
	Georgetown..........	11-57-05	7100	O = 11-57-08	
	La Paz..........	11-56-50	1160	Location approximate.	
	Rio de Janeiro..........	11-56-53	2720		
	San Fernando..........	11-57-21	9280		
	Strasbourg..........	11-57-06	10930		
	Toronto..........	11-57-08	7600		
	Toledo..........	11-57-29	9350		
	Almeria..........	11-57-34	9250		
	Malaga..........	11-57-07	9620		
	Alicante..........	11-57-09	9870		
	La Plata..........	11-56·8	1550		
May 19 2078	Algiers..........	5-24-00	9420	ϕ = 31° S	Ekaterinburg gives
	Athens..........	5-23-46	8800	λ = 58° E	ϕ = 20° 21′ S
	Barcelona..........	5-24-05	9700	O = 5-24-00	λ = 83° 14′ E
	Batavia..........	5-23-51	5750	Location approximate.	
	Helwan..........	5-23-48	7660		Strasbourg gives
	Perth..........	5-22-47	5700		ϕ = 31° S
	Pulkovo..........	5-24-30	9650		λ = 57° E.
	Strasbourg..........	5-24-19	9750		
	Paris..........	5-24-15	9900		
	San Fernando..........	5-24-19	9650		
	Wien..........	5-23-44	10000		
	Zi-ka-wei..........	5-23-56	9560		
	Toledo..........	5-24-16	9680		
	Almeria..........	5-24-07	9500		
	Malaga..........	5-24-04	9600		
	Agram..........	5-24-20	9150		
	Firenze..........	5-24-17	9200		
	Piatigorsk..........	5-23-44	8830		
	Baku..........	5-23-52	8350		
May 20 2079	Ekaterinburg..........	11-04-52	6650	ϕ = 31° N	Ekaterinburg gives
	Paris..........	11-05-08	9980	λ = 143°·5 E	ϕ = 31° 23′ N
	Pulkovo..........	11-04-57	8170	O = 11-04-57	λ = 142° 22′ E.
	Strasbourg..........	11-05-03	9900		
	Baku..........	11-04-51	8150		
	Uccle..........	11-05·0	9550		Kobe gives off Bonin Is.
	Piatigorsk..........	11-04-50	8260		
	Wien..........	11-05-24	9050		
	Zi-ka-wei..........	11-04-46	1990		
	Kobe..........	11-04-34	880		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
May 22	Ekaterinburg........	9–40–17	6620	ϕ = 33° N	Ekaterinburg gives
2083	Paris................	9–40–54	9420	λ = 144° E	ϕ = 31° 49′ N.
	Pulkovo............	9–40–20	8130	O = 9–40–18	λ = 142° 31′ E
	Strasbourg..........	9–40–23	9880		
	Uccle...............	9–40–29	9550		Pulkovo gives
	Zi-ka-wei...........	9–39–50	2150		ϕ = 31° 52′ N
	Taihoku............	9–39–48	2280		λ = 143° 7′ E
	Kobe................	9–40–14	750		
	Baku...............	9–40–17	8060		
May 23	Athens..............	2–10–22	8900	ϕ = 35°·5 N	Strasbourg gives
2084	Batavia.............	2–09–52	5360	λ = 135°·5 E	ϕ = 37° N
	Belgrade............	2–09–49	9000	O = 2–09–48	λ = 134° E
	Ekaterinburg........	2–09–38	5840		
	Hamburg............	2–09–58	8700		Taihoku gives
	Manila..............	2–09–22	2800		ϕ = 35°·7 N
	Paris................	2–09–57	9340		λ = 134°·7 E.
	Pulkovo............	2–09–42	7430		
	Strasbourg..........	2–09–51	9230		
	Uccle...............	2–09–47	9200		
	Wien...............	2–09–44	8950		
	Zi-ka-wei...........	2–10–22	1090		
	Zürich..............	2–09–48	9300		
	Toledo..............	2–10–33	10850		
	Malaga..............	2–10–55	10770		
	Agram..............	2–09–58	8950		
	Firenze.............	2–09–05	9860		
	Baku...............	2–09–46	7210		
	Piatigorsk..........	2–09–33	7480		
May 24	Ekaterinburg........	1–24–28	6000	ϕ = 30° N	
2086	Pulkovo............	1–24–32	7790	λ = 130° E	
	Jinsen..............	1–24–22	1690	O = 1–24–26	
	Wien...............	1–24–44	8890	Location doubtful.	
	Zi-ka-wei...........	1–24–41	790		
	Piatigorsk..........	(1–23–53)	(7600)		
May 25	Batavia.............	3–42–46	2780	ϕ = 12°·5 N	
2087	Pulkovo............	3–43–10	8940	λ = 124°·5 E	
	Wien...............	3–43–03	10250	O = 3–43–14	
	Zi-ka-wei...........	3–43–25	2030		
	Piatigorsk..........	3–42–41	8680		
	Kucino.............	3–43–26	8520		
	Baku...............	3–43–06	7860		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
May 26	Georgetwon........	8-20-00	3100	ϕ = 11° N	
2089	Hamburg..........	8-20-41	8980	λ = 79° W	
	La Paz............	8-21-26	2780	O = 8-20-44	
	Pulkovo...........	8-20-51	9280	Location approxaimte.	
May 26	Ekaterinburg........	15-37-08	6080	ϕ = 24° N	
2090	Pulkovo............	15-37-12	7830	λ = 122°·5 E	
	Zi-ka-wei..........	15-36-30	1110	O = 15-37-04	
	Irkutsk............	15-36-57	3400		
	Baku..............	15-37-20	6740		
	Kucino............	15-37-24	7460		
	Jinsen............	15-36-57	1640		
May 27	Batavia............	2-29-43	5070	ϕ = 41°·5 N	Ekaterinburg gives
2091	Ekaterinburg........	2-29-47	5090	λ = 129°·5 E	ϕ = 41° 57′ N
	Hamburg..........	2-30-30	7600	O = 2-29-55	λ = 130° 49′ E.
	Innsbruck..........	2-30·1	8280		
	Königsberg.........	2-30-07	7310		
	Paris..............	2-30-01	8610		
	Pulkovo...........	2-29-57	6580		
	Strasbourg.........	2-29-59	8400		
	Uccle..............	2-29-07	8290		
	Victoria...........	2-30-01	7170		
	Wien..............	2-29-55	8080		
	Zi-ka-wei..........	2-29-40	1360		
	Zürich............	2-30-04	8400		
	Agram.............	2-29-42	8450		
	Baku..............	2-30-03	6370		
June 2	Ekaterinburg........	5-18-13	5840	ϕ = 42° N	Ekaterinburg gives
2100	Pulkovo............	5-18-20	7200	λ = 144°·2 E	ϕ = 37° 30′ N
	Zi-ka-wei..........	5-17-56	2350	O = 5-18-14	λ = 137° 27′ E.
	Baku..............	5-18-26	7380		
	Mizusawa..........	5-18-17	280		
June 3	Batavia............	4-34-19	2250	ϕ = 3° N	Ekaterinburg gives
2101	Ekaterinburg........	4-34-00	8330	λ = 126° E	ϕ = 0° 55′ S
	Honolulu...........	4-34-23	8180	O = 4-34-01	λ = 120° 36′ E.
	Osaka..............	4-33-50	3660		
	Pulkovo...........	4-34-07	9870		
	Zi-ka-wei..........	4-33-53	3150		
	Kucino............	4-34-23	9200		
	Kobe..............	4-33-50	3850		
	Firenze...........	4-33-37	11720		
	Piatigorsk..........	4-34-06	9210		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
June 4 2103	Ottawa............	12–03–03	3850	ϕ = 43° N	
	Ekaterinburg........	12–03–08	8840	λ = 126° W	
	Pulkovo............	12–03–05	8420	O = 12–03–05	
June 7 2105	Ottawa............	23–41–35	4370	ϕ = 5° N	Cartuja gives
	Algiers............	23–41–49	8540	λ = 75° W	ϕ = 6°·2 N
	Cartuja............	23–41–45	8080	O = 23–41–47	λ = 76°·1 W.
	Eskdalemuir........	23–41–59	8250		
	Georgetown........	23–42–03	3420		Strasbourg gives
	Hamburg............	23–41–55	9020		ϕ = 17° N
	Ithaca............	23–41–44	3960		λ = 78° W.
	La Paz............	23–41–39	2380		
	Paris............	23–41–51	8580		Zürich gives
	Rio de Janeiro.......	23–41–29	4500		ϕ = 10° N
	Strasbourg..........	23–41–53	8910		λ = 75° W.
	Toronto............	23–41–34	4210		
	Uccle............	23–41–47	8750		
	Victoria............	23–41–32	6550		
	Wien............	23–42–11	9300		
	Zürich............	23–41–56	8900		
	Toledo............	23–41–45	8020		
	Moncalieri..........	23–41–40	9010		
June 9 2106	Ekaterinburg........	13–40–58	9420	ϕ = 2° S	Ekaterinburg gives
	Honolulu............	13–40–49	7390	λ = 140° E	ϕ = 8° 51′ S
	Osaka............	13–41–19	3700	O = 13–40–50	λ = 126° 19′ E.
	Perth............	(13–40–22)	3920		
	Pulkovo............	13–40–53	11000		Irkutsk gives
	Baku............	13–40–50	10170		ϕ = 1°·1 S
	Victoria............	13–41–27	9700		λ = 143°·8 E
	Zi-ka-wei..........	13–40–40	4150		
	La Paz............	13–40–54	15800		
	Mizusawa..........	13–40–45	4550		
	Apia............	13–40–43	5450		
	Irkutsk............	13–40–48	6980		
June 11 2109	Ekaterinburg........	15–55–59	9450	ϕ = 3° S	
	Perth............	15–56–50	3850	λ = 137°·5 E	
	Zi-ka-wei..........	15–56–45	4120	O = 15–56–36	
	Irkutsk............	15–56–49	6980		
June 12 2110	Ekaterinburg........	10–58–59	9570	ϕ = 4° S	Ekaterinburg gives
	Honolulu............	10–58–32	7600	λ = 137° E	ϕ = 2° 42′ N
	Perth............	(10–59–07)	3800	O = 10–58– 49	λ = 148° 52′ E.
	Baku............	10–58–37	10420		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
June 13 2112	Cartuja	20-22-14	8650	ϕ = 16° N	
	La Paz	20-23-19	4630	λ = 94° W	
	Strasbourg	20-23	8800	O = 20-23	
	Uccle	20-23·1	9450	Location and O approximate.	
June 14 2115	Ottawa	22-28-09	3070	ϕ = 17° N	
	Cheltenham	22-28-12	2390	λ = 81° W	
	Chicago	22-28-10	2590	O = 22-28-14	
	Georgetown	22-28-13	2420		
	Harvard	22-28-28	2820		
	Ithaca	22-28-02	2860		
	La Paz	22-28-19	3950		
	Pulkovo	22-28-13	9500		
	Toronto	22-28-17	2770		
	Uccle	22-28-15	8350		
June 20 2119	Algiers	13-04-05	5440	ϕ = 39° N	Pulkovo gives
	Barcelona	13-04-08	5470	λ = 68° E	ϕ = 39° 26′ N
	Belgrade	13-04-03	3980	O = 13-04-07	λ = 68° 18′ E.
	Cartuja	13-03-47	6380		
	Eskdalemuir	13-04-02	5500		Strasbourg gives
	Hamburg	13-04-05	4630		ϕ = 39° N
	Innsbruck	13-04·2	4520		λ = 68° E.
	Königsberg	13-04-15	3840		
	Paris	13-04-07	5220		Zürich gives
	Pulkovo	13-04-06	3480		ϕ = 38° N
	Strasbourg	13-03-57	4960		λ = 68° E.
	Uccle	13-04-03	5070		
	Wien	13-04-15	4060		
	Zi-ka-wei	13-03-55	4350		
	Agram	13-04-09	4220		
	Baku	13-04-09	1800		
	Zürich	13-04-08	4740		
	Firenze	13-04-21	4500		
	Toledo	13-04-04	6050		
	Almeria	13-04-04	6100		
	Malaga	13-04-05	6220		
	Piatigorsk	13-04-10	2300		
	Moncalieri	13-04-42	4780		
June 23 2121	Ekaterinburg	4-43-49	5530	ϕ = 42°·5 N	
	Hamburg	4-43-55	8250	λ = 140° E	
	Pulkovo	4-43-52	6900	O = 4-43-59	
	Uccle	4-44-16	8450		
	Baku	4-44-04	7050		
	Mizusawa	4-44-01	340		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
June 23	Ottawa............	16–46–42	4900	ϕ = 1° N	
2122	Georgetown.........	16–46–48	4120	λ = 71°·5 W	
	La Paz............	16–47–02	1820	O = 16–46–54	
	Uccle..............	16–47–02	8950	Location approximate.	
June 28	Ottawa............	1–21–06	2690	ϕ = 45° N	Cartuja gives
2125	Algiers............	1–21–12	8730	λ = 110°·8 W	ϕ = 45° N
	Cartuja............	1–21–06	8380	O = 1–21–06	λ = 112° W.
	Cheltenham........	1–21–09	2810		
	Chicago............	1–21–04	1950		Ekaterinburg gives
	Ekaterinburg........	1–21–14	8580		ϕ = 44° 17′ N
	Eskdalemuir........	1–21–10	6860		λ = 110° 1′ W.
	Fordham...........	1–21–05	2970		
	Georgetown.........	1–21–11	2780		Pulkovo gives
	Hamburg...........	1–21–06	7750		ϕ = 46° 3′ N
	Harvard............	1–20–49	3290		λ = 112° 18′ W.
	Honolulu...........	1–20–55	5040		
	Ithaca.............	1–20–55	2880		Uccle gives
	Königsberg.........	1–21–14	7950		ϕ = 44° N
	La Paz............	1–21–06	8280		λ = 109° W.
	Osaka..............	1–20–12	9160		
	Paris..............	1–21–17	7620		Zürich gives
	Pulkovo............	1–21–12	7770		ϕ = 45° N
	San Fernando.......	1–21–06	8300		λ = 110° W.
	Strasbourg.........	1–21–05	8100		
	Toronto............	1–21–00	2560		Strasbourg gives
	Tucson.............	1–21–48	1370		ϕ = 48° N
	Uccle..............	1–21–07	7690		λ = 112° W.
	Wien...............	1–21–06	8500		
	Zi-ka-wei..........	1–21–16	9980		
	Zürich.............	1–21–11	8160		
	Halifax............	1–20–50	3680		
	New Orleans........	1–20–55	2200		
	Agram.............	1–21–10	8650		
	Bergen.............	1–21	6450		
	Moncalieri..........	1–21–08	8350		
	Sitka..............	1–21–00	2140		
	Firenze............	1–21–08	8700		
	Toledo.............	1–21–04	8220		
	Almeria............	1–21–16	8400		
	Malaga.............	1–21–11	8320		
	Alicante...........	1–21–01	8430		
	Kucino.............	1–21–21	8200		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
June 28 2128	Belgrade	6-13-10	9480	ϕ = 29° N	Ekaterinburg gives
	Cartuja	6-13-51	10750	λ = 130° E	ϕ = 28° 45′ N
	Ekaterinburg	6-13-56	6110	O = 6-13-53	λ = 129° 37′ E.
	Eskdalemuir	6-14-16	9340		
	Paris	6-13-47	9800		
	Pulkovo	6-13-58	7890		
	Strasbourg	6-14-16	9340		
	Uccle	6-14-07	9450		
	Wien	6-13-56	9350		
	Zi-ka-wei	6-13-14	900		
	Jinsen	6-14-04	1060		
	Kobe	6-13-54	890		
	Kucino	6-13-55	7640		
June 28 2129	Ekaterinburg	13-41-44	5720	ϕ = 12° N	Ekaterinburg gives
	Paris	13-41-32	9450	λ = 95° E	ϕ = 14° 8′ N
	Pulkovo	13-41-53	7350	O = 13-41-41	λ = 98° 27′ E.
	Uccle	13-41-41	9130		
	Wien	13-41-34	8380		Irkutsk gives
	Irkutsk	13-41-44	4560		ϕ = 11°·6 N
	Baku	13-41-36	5360		λ = 95°·3 E.
June 29 2131	Ottawa	14-42-04	3900	ϕ = 33°·5 N	Irkutsk gives
	Belgrade	14-42-43	9900	λ = 118°·5 W	ϕ = 37°·5 N
	Cartuja	14-42-28	9560	O = 14-42-16	λ = 118°·3 W.
	Cheltenham	14-42-40	3510	Destructive quake at	
	Chicago	(14-43-43)	2400	Santa Barbara, Cali-	
	Ekaterinburg	14-42-33	9630	fornia.	
	Eskdalemuir	14-42-32	8360		
	Fordham	14-42-34	3840		
	Georgetown	14-42-00	3880		
	Hamburg	14-42-20	9230		
	Harvard	14-41-58	4420		
	Honolulu	14-41-20	4370		
	Ithaca	14-42-09	3820		
	Paris	14-42-17	9320		
	Pulkovo	14-42-14	9450		
	San Fernando	14-42-26	9660		
	Toronto	14-42-10	3550		
	Uccle	14-42-12	9350		
	Almeria	14-42-22	9400		
	Malaga	14-42-18	9770		
	Irkutsk	14-42-26	9440		
	Kucino	14-42-10	10000		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
July 5 2143	Cartuja	7-01-51	4870	ϕ = 15° N	
	Ekaterinburg	7-02-24	9320	λ = 45° W	
	Pulkovo	7-02-00	7890	O = 7-02-03	
	Toledo	7-02-01	4780	Location approximate.	
	Almeria	7-02-01	4815		
	Malaga	7-02-04	4620		
July 6 2146	Baku	12-15-20	2650	ϕ = 38°	Athens gives
	Cartuja	12-15-37	2290	λ = 22° E	ϕ = 37°·8 N
	Ekaterinburg	12-15-51	3280	O = 12-15-40	λ = 22°·1 E.
	Eskdalemuir	12-15-48	2600		
	Hamburg	12-15-45	2000		
	Helwan	12-16-11	1040		Ekaterinburg gives
	Innsbruck	12-16-06	1210		ϕ = 38° 49′ N
	Lemberg	12-15-48	1380		λ = 24° 50′ E.
	Piatigorsk	12-15-46	1910		
	Paris	12-15-47	1980		
	Pulkovo	12-15-46	2440		Pulkovo gives
	San Fernando	12-15-42	2640		ϕ = 38° 40′ N
	Strasbourg	12-15-37	1740		λ = 20° 55′ E.
	Uccle	12-15-52	1980		
	Wien	12-15-26	1390		
	Zürich	12-16-04	1390		
	Agram	12-15-58	940		Strasbourg and Zürich give
	Bergen	12-14-07	2560		ϕ = 36° N
	Toledo	12-15-41	2260		λ = 21° E.
	Almeria	12-15-33	2280		
	Malaga	12-15-33	2390		
	Alicante	12-15-35	2030		
July 7 2149	Ottawa	14-12-04	4080	ϕ = 20° N	
	Cartuja	14-11-59	10310	λ = 107° W	
	Chicago	14-12-20	3040	O = 14-12-20	
	Ekaterinburg	14-12-23	11220		
	Eskdalemuir	14-12-40	8980		
	Fordham	14-12-07	3910		
	Georgetown	14-12-07	3580		
	Harvard	14-12-08	4220		
	Honolulu	14-12-25	5280		
	La Paz	14-12-19	5820		
	Paris	14-12-36	9650		
	Pulkovo	14-12-28	10230		
	Toronto	14-12-06	3700		
	Tucson	14-12-37	1500		
	Uccle	14-12-17	9900		
	Victoria	14-12-23	3400		
	Irkutsk	14-12-27	11280		
	Toledo	14-12-27	9680		
	Malaga	14-12-28	9770		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
July 7 2151	Ottawa	17-43-36	3200	ϕ = 18° N	
	Algiers	17-43-37	6530	λ = 61·5 W	
	Cartuja	17-43-32	5960	O = 17-43-34	
	Cheltenham	17-43-28	2820		
	Chicago	17-43-36	3560		
	Fordham	17-43-25	2840		
	Georgetown	17-43-22	2900		
	Hamburg	17-43-37	7250		
	Harvard	17-43-29	2880		
	Ithaca	17-43-28	3050		
	Paris	17-43-35	6650		
	Pulkovo	17-43-34	8540		
	Strasbourg	17-43-45	6860		
	Toronto	17-43-38	3170		
	Uccle	17-43-37	6750		
	Wien	17-43-30	7800		
	Toledo	17-43-34	5880		
	Almeria	17-43-33	6010		
	Malaga	17-43-42	5810		
July 17 2160	Ekaterinburg	3-13-59	8350	ϕ = 12° N	Ekaterinburg gives
	Osaka	3-13-52	2550	λ = 142°·5 E	ϕ = 12° 26′ N
	Pulkovo	3-14-15	9500	O = 3-13-53	λ = 142° 21′ E.
	Victoria	3-13-58	9300		
	Baku	3-13-22	10140		Pulkovo gives
					ϕ = 35° 31′ N
					λ = 160° 45′ E.
July 17 2163	Ekaterinburg	21-07-42	9780	ϕ = 2° S	Ekaterinburg gives
	Pulkovo	21-07-52	11050	λ = 139° E	ϕ = 5° 16′ N
	Honolulu	21-07-55	7340	O = 21-07-50	λ = 138° 40′ E.
				Location approximate.	
July 31 2170	Cartuja	8-46-30	8300	ϕ = 6° N	
	La Paz	8-44-52	2860	λ = 80° W	
	Rio de Janeiro	8-45-58	5060	O = 8-46-02	
	Toronto	8-46-24	4080	Location approximate.	
	Uccle	8-46-28	8950		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 7	Agram	6-46-31	1530	ϕ = 38° N	Pulkovo gives
2177	Algiers	6-46-37	2370	λ = 30°·3 E	ϕ = 38° 24′ N
	Athens	6-46-51	480	O = 6-46-30	λ = 25° 36′ E.
	Almeria	6-46-36	2825		
	Barcelona	6-46-31	2420		
	Cartuja	6-46-22	3030		
	Eskdalemuir	6-46-31	3110		Strasbourg gives
	Firenze	6-46-31	1800		ϕ = 38° N
	Hamburg	6-46-29	2390		λ = 30° E.
	Lemberg	6-45·8	1680		
	Naples	6-46-10	1640		
	Paris	6-46-25	2580		
	Pulkovo	6-46-43	2400		
	Strasbourg	6-46-33	2200		
	Toledo	6-46-20	3000		
	Uccle	6-46-28	2540		
	Wien	6-46-49	1550		
	Zürich	6-46-40	2040		
Aug. 7	Ottawa	7-47-40	3600	ϕ = 19°·5 N	
2178	Cartuja	7-47-50	9310	λ = 100°·5 W	
	Chicago	7-47-49	2780	O = 7-47-50	
	Georgetown	7-47-44	3330		
	La Paz	7-47-39	5280		
	Strasbourg	7-47-54	9600		
	Toronto	7-47-48	3190		
	Tucson	7-48-10	1620		
	Uccle	7-47-59	9200		
	Victoria	7-47-33	3700		
	Denver	7-48	2440		
	Almeria	7-48-15	9140		
Aug. 12	Cartuja	6-58-45	4080	ϕ = 23°·5 N	Cartuja gives
2183	Ekaterinburg	6-58-47	8840	λ = 46° W	ϕ = 26° N
	Georgetown	6-58-26	3400	O = 6-58-42	λ = 45° W.
	Hamburg	6-58-30	5780		
	La Paz	6-58-34	5125		
	Paris	6-58-50	4830		
	Pulkovo	6-58-54	7050		
	Strasbourg	6-58-36	5420		
	Uccle	6-58-35	5240		
	Victoria	6-59-06	7010		
	Toledo	6-58-42	4150		
	Malaga	6-58-46	4150		
	Almeria	6-58-39	4300		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 16 2190	Ekaterinburg........	2-25-13	4950	ϕ = 51° N	Ekaterinburg gives
	Pulkovo..........	2-25-31	6250	λ = 142° E	ϕ = 53° 10′ N
	Uccle........	2-25-27	7920	O = 2-25-20	λ = 144° 38′ E.
	Toledo..........	2-25-11	9600	Location approximate.	
Aug. 19 2193	Cartuja............	5-25-08	9780	ϕ = 53° N	
	Uccle............	5-25-00	8540	λ = 170° W	
	Victoria...........	5-24-47	3250	O = 5-25-02	
	Toledo............	5-25-15	9330		
Aug. 19 2194	Ottawa............	12-07-30	7390	ϕ = 55° N	Ekaterinburg gives
	Almeria............	12-07-29	9605	λ = 166° E	ϕ = 53° 2′ N
	Algiers............	12-07-48	9350	O = 12-07-31	λ = 163° 39′ E.
	Alicante...........	12-07-41	9400		
	Athens............	12-07-40	9010		
	Barcelona..........	12-07-30	9300		
	Belgrade..........	12-07-31	8540		Pulkovo gives
	Berkeley..........	12-07-35	5450		ϕ = 52° 22′ N
	Cartuja............	12-07-32	9620		λ = 161° 21′ E.
	Chicago...........	12-07-05	7350		
	Ekaterinburg.......	12-07-16	5950		Strasbourg gives
	Eskdalemuir.......	12-07-25	7790		ϕ = 56° N
	Fordham..........	12-07-47	7950		λ = 163° E.
	Georgetown........	12-07-31	7920		
	Hamburg..........	12-07-23	7920		
	Helwan...........	12-07-47	9340		
	Honolulu..........	12-07-08	4830		
	Ithaca............	12-07-42	7480		
	Naples...........	12-07-17	9000		
	Paris.............	12-07-33	8380		
	Malaga...........	12-07-30	9680		
	Moncalieri.........	12-07-28	8640		
	Pulkovo...........	12-07-20	6820		
	San Fernando......	12-07-19	9800		
	Strasbourg.........	12-07-27	8450		
	Mizusawa..........	12-07-22	2640		
	Toronto...........	12-07-23	7500		
	Toledo............	12-07-38	9280		
	Uccle.............	12-07-31	8170		
	Victoria...........	12-07-12	4680		
	Wien.............	12-07-23	8360		
	Zi-ka-wei.........	12-07-31	4260		
	Zürich............	12-07-41	8360		
	Agram............	12-07-32	8550		
	Piatigorsk.........	12-07-43	7740		
	Kucino...........	12-08-02	6950		
	Irkutsk...........	12-07-33	3780		
	Firenze...........	12-07-38	8800		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 29 2202	Ottawa	22–36–39	3560	ϕ = 25° N	
	Cartuja	22–36–46	9580	λ = 109° W	
	Chicago	22–36–23	2760	O = 22–36–35	
	Victoria	22–36–18	2820		
	Toledo	22–36–43	9480		
	Almeria	22–36–39	9600		
Sept. 4 2215	Ottawa	10–36–01	3500	ϕ = 18° N	
	Chicago	10–36–18	2720	λ = 96° W	
	Toronto	10–36–05	3190	O = 10–36–08	
				Location approximate.	
Sept. 5 2216	Ekaterinburg	16–30–11	6170	ϕ = 54° N	Irkutsk gives
	Georgetown	16–30–21	7820	λ = 171° E	ϕ = 57° N
	San Fernando	16–30–19	9740	O = 16–30–17	λ = 165·8 E.
	Victoria	16–30–06	4400		
	Irkutsk	16–30–34	3850		
	Toledo	16–30–34	9400		
	Mizusawa	16–29–51	2880		
Sept. 24 2229	Algiers	4–38–11	5130	ϕ = 30°·5 N	
	Helwan	4–38–31	2410	λ = 58° E	
	Pulkovo	4–38–42	3970	O = 4–38–34	
	Uccle	4–38–38	4950		
	Wien	4–38–36	4000		
	Piatigorsk	4–38–47	2200		
Sept. 25 2232	Ekaterinburg	8–45–21	8000	ϕ = 6° S	Ekaterinburg gives
	Pulkovo	8–45–25	9520	λ = 102° E	ϕ = 5° 37′ S
	Zi-ka-wei	8–45–02	4630	O = 8–45–16	λ = 104° 48′ E.
				Location approximate.	
Sept. 29 2236	Alicante	17–32–52	7210	ϕ = 19° N	
	Fordham	17–33–52	2590	λ = 74°·5 W	
	Georgetown	17–33–40	2620	O = 17–33–44	
	Hamburg	17–33–53	7200		
	Ithaca	17–34–09	2730		
	Wien	17–33–54	7660		
	Pulkovo	17–34–12	8200		
	Toronto	17–33–29	3120		
	Uccle	17–33–37	6920		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 5	Ottawa............	4-09-05	3450	ϕ = 14° N	St. Louis gives
2244	Algiers............	4-09-15	8800	λ = 84°·5 W	ϕ = 13° N
	Berkeley............	4-09-06	4210	O = 4-09-07	λ = 84° W.
	Fordham............	4-09-04	3120		
	Georgetown............	4-09-11	2820		Strasbourg gives
	Ithaca............	4-09-02	3180		ϕ = 15° N
	La Paz............	4-09-06	3500		λ = 83° W.
	Paris............	4-09-15	8550		
	Pulkovo............	4-09-14	9780		
	Rio de Janeiro............	4-09-00	5870		
	San Fernando............	4-09-10	8180		
	Strasbourg............	4-09-18	8800		
	Toronto............	4-08-55	3350		
	Uccle............	4-09-07	8740		
	Victoria............	4-09-13	4860		
	Halifax............	4-09-09	3850		
	Firenze............	4-08-57	9400		
	La Plata............	4-09·1	5770		
	Alicante............	4-09-05	8410		
	Toledo............	4-09-04	8300		
	Malaga............	4-09-10	8240		
	Leningrad............	4-09-14	9750		
Oct. 5	Ottawa............	4-11-07	3050	ϕ = 18° N	
2245	Toronto............	4-11-00	2880	λ = 81° W	
	Halifax............	4-11-18	3400	O = 4-11-08	
Oct. 12	Algiers............	5-44-49	9550	ϕ = 33° S	Strasbourg gives
2249	Makéevka............	5-44-38	9200	λ = 59° E	ϕ = 33° S
	Barcelona............	5-44-45	10100	O = 5-44-46	λ = 57° E.
	Toledo............	5-44-31	10470		
	Batavia............	5-44-42	5780		
	Ekaterinburg............	5-45-11	9450		
	Strasbourg............	5-44-42	10420		
	Wellington............	5-44-49	9340		
	Wien............	5-44-35	9970		
	Moncalieri............	5-44-22	10320		
	Zi-ka-wei............	5-44-57	9330		
	Firenze............	5-44-58	9700		
	Graz............	5-45-03	9400		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 13	Ottawa	17-40-32	4900	ϕ = 10°·5 N	St. Louis gives
2250	Algiers	17-40-46	5080	λ = 43° W	ϕ = 10° N
	Barcelona	17-40-27	5510	O = 17-40-31	λ = 42° W.
	Belgrade	17-39-58	6780		
	St. Louis	17-40-27	5650		Ekaterinburg gives
	Ekaterinburg	17-40-57	9420		ϕ = 15° 3′ N
	Fordham	17-40-32	4450		λ = 43° 58′ W.
	Georgetown	17-39-30	4580		
	Hamburg	17-40-53	6300		Pulkovo gives
	Helwan	17-40-41	7860		ϕ = 6° 38′ N
	Innsbruck	17-40-30	6450		λ = 37° 17′ W.
	Ithaca	17-40-36	4700		
	La Paz	17-40-42	3920		Strasbourg gives
	Paris	17-40-33	5850		ϕ = 9°·5 N
	Pulkovo	17-40-32	8130		λ = 38°·5 W.
	Strasbourg	17-40-34	6180		
	Moncalieri	17-40-25	6160		Leningrad gives
	San Fernando	17-40-26	4620		ϕ = 11° 12′ N
	Kucino	17-40-49	8560		λ = 44° 44′ W.
	Toronto	17-40-33	5020		
	Uccle	17-40-26	6190		
	Victoria	17-40-36	8500		
	Wien	17-40-29	6900		
	Zürich	17-40-31	6250		
	Agram	17-40-46	6520		
	Firenze	17-40-33	6340		
	Graz	17-40-36	6650		
	Makéevka	17-40-23	8440		
	La Plata	17-40·6	5220		
	Alicante	17-40-11	5450		
	Almeria	17-40-23	4940		
	Leningrad	17-40-38	8060		
	Toledo	17-40-29	4890		
Oct. 14	Ekaterinburg	10-23-33	5700	ϕ = 43° N	
2251	Pulkovo	10-23-38	7100	λ = 143° E	
	Irkutsk	10-24-25	3080	O = 10-23-40 ca.	
				Location approximate.	
Oct. 15	Pulkovo	12-36-19	6350	ϕ = 26° N	Irkutsk gives
2254	Zi-ka-wei	12-36-10	2210	λ = 99°·5 E	ϕ = 27°·0 N
	Makéevka	12-35-58	5820	O =12-36-14	λ = 102°·5 E.
	Kucino	12-36-20	5780		
	Baku	12-36-21	4740		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 18	Batavia............	8–26–01	2420	ϕ = 5° N	
2259	Zi-ka-wei..........	8–25–37	3050	λ = 124° E	
	Makéevka.........	8–26–04	8980	O = 8–25–55	
				Location approximate.	
Oct. 22	Batavia..........	17–01–48	410	ϕ = 4° S	Irkutsk gives
2263	Ekaterinburg.......	17–01–46	7830	λ = 103°·5 E	ϕ = 3°·9 S
	Helwan............	17–01–52	8420	O = 17–01–43	λ = 104°·3 E.
	Perth............	17–01–23	3360		
	Wien............	17–01–44	10020		
	Zi-ka-wei.........	17–01–40	4350		
	Jinsen............	17–01–41	5220		
	Makéevka.........	17–01–47	8350		
	Irkutsk...........	17–01–47	6240		
	Baku............	17–01–45	7400		
Oct. 23	Batavia...........	1–47–46	870	ϕ = 10°·5 S	Ekaterinburg gives
2264	Ekaterinburg.......	1–47–33	8920	λ = 114°·2 E	ϕ = 8° 57′ S
	Zi-ka-wei..........	1–47–27	4630	O = 1–47–36	λ = 116° 31′ E.
	Baku.............	1–47–38	8670		
Oct. 25	Batavia............	0–21–20	2400	ϕ = 3° N	Ekaterinburg gives
2266	Ekaterinburg........	0–21–25	8250	λ = 126° E	ϕ = 0° 14′ N
	Pulkovo...........	0–21–24	9890	O = 0–21–24	λ = 121° 15′ E.
	Makéevka..........	0–21–14	9280	Location approximate.	
	Baku.............	0–21–23	8740		
	Kucino............	0–21·6	9520		
Oct. 30	Batavia............	14–41–44	5920	ϕ = 9° S	Irkutsk gives
2268	Zi-ka-wei..........	14–41–51	5980	λ = 161° E	ϕ = 4°·5 N
	Irkutsk............	14–41–47	8670	O = 14–41–46	λ = 180°·6 E.
	Wellington.........	14–41–43	3500	Location approximate.	

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 10	Batavia	13–50–15	2780	ϕ = 2° S	Ekaterinburg gives
2277	Ekaterinburg	13–50–44	8780	λ = 127° E	ϕ = 1° 49′ S
	Wellington	13–50–45	6110	O = 13–50–36	λ = 127° 10′ E.
	Osaka	13–50–16	4260	Location and O	
	Leningrad	13–50–32	10480	approximate	Irkutsk gives
	Pulkovo	13–50–47	10300		ϕ = 3°·2 N
	Kucino	13–50–44	10050		λ = 142°·1 E.
	Irkutsk	13–50–25	6460		
	Nagasaki	13–50–04	4000		Apia gives
	Apia	13–50–39	6600		ϕ = 2° S
	Makéevka	13–50–51	9580		λ = 129° E.
	Piatigorsk	13–50–58	9400		
	Ootomari	13–50–46	5400		
Nov. 13	Batavia	12–14–25	3040	ϕ = 13° N	Ekaterinburg gives
2278	Ekaterinburg	12–14–45	7320	λ = 126°·5 E	ϕ = 12° 58′ N
	Wellington	12–15–08	7460	O = 12–14–50	λ = 125° 2′ E.
	Lemberg	12–14·8	9520		
	Manila	12–14–51	510		Wellington gives
	Pulkovo	12–14–50	9000		ϕ = 12° 30′ N
	Leningrad	12–14–48	9020		λ = 126° E.
	Kucino	12–14–44	8800		
	Irkutsk	12–14–35	4700		Pulkovo gives
	Zi-ka-wei	12–14–55	2000		ϕ = 15° 26′ N
	Firenze	12–15–04	10500		λ = 128° 54′ E.
	Nagasaki	12–14–48	2280		
	Ootomari	12–14–37	4210		Leningrad gives
	Taihoku	12–15–14	1320		ϕ = 13° 48′ N
	Piatigorsk	12–14–46	8360		λ = 125° 35′ E.
	Apia	12–14–59	7530		
Nov. 14	Ekaterinburg	10–03–34	7320	ϕ = 15° N	
2280	Pulkovo	10–03–32	9090	λ = 131° E.	
	Zi-ka-wei	10–03–23	2150	O = 10–03–30	
	Irkutsk	10–03–26	9660	Location approximate.	
	Baku	10–03–31	7980		
	Kucino	10–03–35	8650		
Nov. 14	Ekaterinburg	14–37–12	7240	ϕ = 14° N	
2281	Pulkovo	14–37–15	8940	λ = 127° E	
	Zi-ka-wei	14–36–58	2130	O = 14–37–04	
	Irkutsk	14–36–58	4660		
	Baku	14–36–56	8100		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 14	Ekaterinburg........	22–35–42	6350	ϕ = 41° N	
2282	Uccle.............	22–35–25	2850	λ = 30° W	
	Almeria...........	22–35–38	2200	O = 22–35–32	
	Malaga............	22–35–25	2100	Location approximate.	
Nov. 16	Ottawa............	11–54–50	4040	ϕ = 17°·5 N	St. Louis gives
2283	Berkeley...........	11–54–24	2880	λ = 103°·5 W	ϕ = 16°·5 N
	St. Louis...........	11–54–55	2730	O = 11–54–51	λ = 106° W
	Fordham...........	11–53–38	4420		
	Georgetown.........	11–54–42	3580		
	Halifax............	11–54–40	4880		
	Ithaca.............	11–55–03	3660		
	Paris..............	11–54–51	9900		
	Rio de Janeiro.......	11–54–59	8350		
	Toronto............	11–55–06	3490		
	Uccle..............	11–54–57	9820		
	Victoria...........	11–54–42	3600		
	Denver............	11–55	2440		
	La Plata...........	11–55·1	7850		
	Bergen............	11–55–00	9200		
	Malaga............	11–55–23	9520		
	Toledo............	11–54–55	9500		
	Almeria...........	11–54–48	10000		
	Alicante...........	11–55–30	9470		
Nov. 17	Ottawa............	0–17–50	6120	ϕ = 11° S	
2285	La Paz............	0–17–53	1470	λ = 79° W	
	Rio de Janeiro.......	0–17–40	4080	O = 0–17–50	
	San Fernando.......	0–17–49	9340		
	Victoria...........	0–17–48	7900		
	Almeria...........	0–18–05	9500		
	Malaga............	0–17–55	9430		
Nov. 28	Ekaterinburg........	8–14–41	3840	ϕ = 70° N	
2290	Pulkovo...........	8–14–43	2490	λ = 19° W	
	Leningrad..........	8–14–46	2460	O = 8–14–43	
Nov. 28	Ottawa............	12–33–28	3270	ϕ = 16° N	
2291	Fordham...........	12–33–27	2960	λ = 79° W.	
	Ithaca.............	12–33–33	2980	O = 12–33–28	
	La Paz............	12–33–27	3850	Location approximate.	
	Toronto............	12–33–23	3030		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 28 2292	Ekaterinburg	16–14–01	11900	ϕ = 11° S	Apia gives
	Victoria	16–13–48	9500	λ = 165° E	ϕ = 17° S
	Apia	16–13–00	2480	O = 16–13–40	λ = 164° E.
	Irkutsk	16–13–47	9470	Location approximate.	
Dec. 7 2294	Ekaterinburg	8–34–31	2400	ϕ = 38° N	Ekaterinburg gives
	Pulkovo	8–34–28	3900	λ = 76°·7 E	ϕ = 38° 49′ N
	Irkutsk	8–34–24	2640	O = 8–34–24	λ = 78° 46′ E.
	Baku	8–34–11	2440		
	Leningrad	8–34–28	3900		Irkutsk gives
					ϕ = 42°·2 N
					λ = 72°·2 E.
Dec. 10 2297	Ottawa	14–14–36	3680	ϕ = 14° N	U.S. Coast and Geodetic Survey gives
	Algiers	14–14–50	9560	λ = 93° W	ϕ = 13° N
	Balboa	14–14–37	1900	O = 14–14–40	λ = 93° W.
	Berkeley	14–14–36	3810		
	Cheltenham		2810		Strasbourg gives
	Chicago	14–14–50	2820		ϕ = 15°·5 N
	Fordham	14–14–55	3250		λ = 89°·5 W.
	Georgetown	14–14–22	3240		
	Hamburg	14–15–06	9300		
	Honolulu	14–15·0	6860		
	Paris	14–15–06	8950		
	Pulkovo	14–14–51	10200		
	Strasbourg	14–14–48	9650		
	Toronto	14–14–31	3410		
	Tucson	14–14–39	2770		
	Uccle	14–15–03	9070		
	Victoria	14–14–36	4690		
	Port au Prince	14–14–08	2660		
	Toledo	14–14–54	8820		
	Almeria	14–14–58	8900		
	Malaga	14–14–57	8800		
	Alicante	14–14–45	9100		
	Moncalieri	14–14–17	9850		
Dec. 19 2307	Georgetown	16–09–36	8620	ϕ = 31° ·7 S	U.S. Coast and Geodetic Survey gives
	Ithaca	16–09–33	9000	λ = 112° W	ϕ = 31° S
	La Paz	16–09–17	4710	O = 16–09–32	λ = 112° W.
	Victoria	16–09–42	8940		
	Wellington	16–09–31	6620		

LOCATION OF EPICENTRES, 1925

Date	Station	O	Δ	Epicentre	Other Locations
Dec. 22	Algiers............	5-05-42	9300	ϕ = 20° N	U.S. Coast and Geodetic
2308	Batavia............	5-05-27	2960	λ = 101°·7 E	Survey gives
	Ekaterinburg........	5-05-22	5250	O = 5-05-33	ϕ = 20° N
	Hamburg..........	5-05-45	8260		λ = 100° E
	Helwan............	5-05-35	7050		
	Manila............	5-06-01	1950		Zürich gives
	Pulkovo............	5-05-17	7200		ϕ = 15° N
	Zi-ka-wei..........	5-05-26	2360		λ = 97° E.
	Zürich............	5-05-37	8620		
	Taihoku............	5-05-30	2160		Irkutsk gives
	Irkutsk............	5-05-27	3420		ϕ = 21°·6 N
	Baku..............	5-05-19	5400		λ = 107°·2 E.
	Kucino............	5-06·0	6670		
	Leningrad..........	5-05-19	7180		
Dec. 27	Batavia............	10-27-55	2480	ϕ = 2° N	Ekaterinburg gives
2311	Ekaterinburg........	10-28-20	8350	λ = 128° E	ϕ = 3° 34′ S
	Pulkovo............	10-28-26	9890	O = 10-28-22	λ = 115° 30′ E.
	Makéevka..........	10-28-59	9200	Location approximate.	
	Irkutsk............	10-28-15	6000		Irkutsk gives
	Baku..............	10-28-13	8820		ϕ = 1°·4 N
	Kucino............	10-28·4	9650		λ = 128° E.
	Leningrad..........	10-28-24	9980		
Dec. 29	Ekaterinburg........	16-04-19	8330	ϕ = 1° S	U.S. Coast and Geodetic
2316	Zi-ka-wei..........	16-04-06	3530	λ = 121°·5 E	Survey gives
	Irkutsk............	16-04-12	6120	O = 16-04-13	ϕ = 1° S
	Baku..............	16-04-17	8500		λ = 120° E.
					Ekaterinburg gives
					ϕ = 3° 11′ S
					λ = 116° 28′ E.
					Irkutsk gives
					ϕ = 0°·7 N
					λ = 127°·4 E.

[illegible]

Date	Place	[illegible]	[illegible]	Ephemeris	Other Locations
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

DEPARTMENT OF THE INTERIOR
CANADA

HON. CHARLES STEWART, *Minister* W. W. CORY, C.M.G., *Deputy Minister*

PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

R. MELDRUM STEWART, *Director*

Vol. VII

Seismology

No. 5

THE LOCATION OF EPICENTRES, 1926-7

BY

W. W. DOXSEE

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1930

THE LOCATION OF EPICENTRES, 1926-27

During the two-year period beginning January 1st, 1926, and ending December 31st 1927, Greenwich dates, seven hundred and ten earthquakes were recorded by the seismographs at the Ottawa station. The data collected from the Seismological Bulletins supplied to the Dominion Observatory from the many co-operating stations made possible the determination of the epicentres for two hundred and twenty-four of these earthquakes. The summary, giving the results for each month of the two years, is as follows:

Month	Total Number of Quakes Recorded		Number for which epicentre was determined	
	Year 1926	Year 1927	Year 1926	Year 1927
January	25	28	8	6
February	26	26	5	11
March	32	36	9	13
April	28	24	6	5
May	22	24	6	7
June	30	28	10	9
July	50	33	14	14
August	38	43	10	19
September	37	27	9	11
October	34	31	17	7
November	22	35	10	12
December	17	14	3	3
Totals	361	349	107	117

The following symbols of the modified international notation are used:—

P Normal first preliminary tremors—longitudinal waves that have passed below the continental layer; and time of their arrival.

S Normal second preliminary tremors—transverse waves that have passed below the continental layer; and time of their arrival.

L Long waves of irregular form at the beginning of the surface or main phase; and time of their arrival.

i Impulsive and sharply defined beginning of a phase.

e Poorly defined emergence of a phase.

O Time of earthquake at the epicentre (Time quoted in the text is Greenwich Mean Time.

Δ Arcual distance from station to epicentre in kilometers.

ϕ Geographical latitude.

λ Geographical longitude from Greenwich.

As in the preceding issues, the anaylsis covered by this publication is confined to those earthquakes of which some record was obtained at this station. The first column of the tabulation gives the Greenwich date of the earthquake followed by its Ottawa serial number, which forms a ready reference to the seismogram interpretation as given in the Seismological Bulletin.

The second column lists only those stations at which the earthquake record was interpreted in terms of P and S. In many instances the number of stations might have been augmented by interpreting their recorded e or i readings as the preliminary tremors, but this practice was restricted to the case of Ottawa where the seismogram was available for further study. Locations, as given, are based on data from at least three stations. As two stations are operating at Chicago, one under the jurisdiction of the United States Coast and Geodetic Survey and the other under the control of Loyola College, the latter is distinguished by a bracketed L after the name Chicago. The values of O and Δ, as computed from the Klotz Tables, are given in the third and fourth columns, respectively. The geographical co-ordinates of the epicentre, as determined by means of the stereographic projection method, together with the most probable value of O, are tabulated in column five. The last column quotes from the bulletins of other stations their reported location of the epicentre.

In a study to determine whether any relation existed between seismogram characteristics and the origin of the earthquake, it was noticed that O and Δ values could be obtained from Ottawa records for a much greater percentage of the South American earthquakes than for those originating in Alaska or the Aleutian islands. The distances from Ottawa to both regions are of the same order, and the intensity factor would appear to favour the recording of a greater number of the Aleutian quakes. This leaves as one cause the directional effect, and it seems reasonable to assume that the North–South and East–West orientation of the seismographs of this station may be a contributing factor toward the better recording of quakes originating at points to the south than of those whose origins lie to the northwest. This same characteristic for the two groups of L waves is dealt with in a paper by L. Don Leet, entitled "An Empirical Investigation of Surface Waves Generated by Distant Earthquakes," which is to appear as Vol. VII, No. 6, of the publications of this Observatory.

A survey of the distribution of seismic activity shows that more than half of the epicentres determined were for earthquakes with origins in the Pacific. However, considerable activity took place in the North Atlantic just west of the Azores and also in the Indian Ocean to the southwest of the island of Madagascar. Three of the earthquakes occurring in the Arctic region were found to have unusual epicentres, No. 2686 of January 7th, 1927, at 80° N. Latitude and 116° E. longitude, and Nos. 2992 and 2993 of November 14th, 1927, in the North Russian mainland.

With the locations computed by Prof. H. H. Turner, of Oxford, appearing quarterly and with arrangements completed whereby preliminary determinations are made by the United States Coast and Geodetic Survey of the origins of all large earthquakes, the requirements of this phase of seismology are amply provided for. For this reason the location of epicentres is being discontinued as a part of the program of this station, this publication for the years 1926 and 1927 being the final issue of the continuous series begun in 1911.

DOMINION OBSERVATORY,
OTTAWA, CANADA,
January, 1930.

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Jan. 1	Belgrade	18–04–04	675	ϕ = 46° N	Strasbourg gives
2318	Uccle	18–04–20	880	λ = 13°·5 E	ϕ = 45° 45′ N
	Agram	18–04–07	200	O = 18–04–10	λ = 14° 20′ E
	Toledo	18–04–19	1730		
	Almeria	18–04–06	1780		Zürich gives
	Zürich	18–04–14	480		ϕ = 45°·6 N
					λ = 14°·2 E
Jan. 1	Ottawa	21–37–25	7500	ϕ = 22° S	Sucre gives
2319	Georgetown	21–37–22	6820	λ = 70° W	ϕ = 25° 5′ S
	LaPaz	21–37–46	570	O = 21–37–27	λ = 70°·5 W
	Toronto	21–37–20	7340		
	La Plata	21–37–09	1820		
	Sucre	21–37–20	700		
	Toledo	21–37–26	9680		
Jan. 7	Ottawa	14–31–07	3290	ϕ = 33° N	
2326	LaPaz	14–31–20	6170	λ = 40°·5 W	
	Sucre	14–31–05	6560	O = 14–31–15	
	Baku	14–31–29	7700		
	Irkutsk	14–31–20	9800		
Jan. 13	Algiers	1–46–49	2250	ϕ = 38° N	Leningrad gives
2327	Leningrad	1–46–48	2410	λ = 29° E	ϕ = 37° 55′ N
	Ekaterinburg	1–47–11	2880	O = 1–46–52	λ = 30° 18′ E
	Hamburg	1–46–45	2260		
	Pulkovo	1–46–41	2430		
	Strasbourg	1–46–51	2050		
	Uccle	1–46–51	2330		
	Makéevka	1–46–39	1450		
	Baku	1–47–00	1840		
	Kucino	1–47–08	1980		
Jan. 13	Leningrad	8–08–29	2430	ϕ = 38° N	
2328	Ekaterinburg	8–08–49	2930	λ = 31° E	
	Hamburg	8–08–18	2340	O = 8–08–28	
	Innsbruck	8–08–10	2000		
	Pulkovo	8–08–25	2440		
	Strasbourg	8–08–35	2050		
	Makéevka	8–08–22	1450		
	Irkutsk	8–08–33	5870		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Jan. 18	Algiers	21-07-30	9620	ϕ = 3° S	Leningrad gives
2331	Barcelona	21-07-46	9550	λ = 88°·7 E	ϕ = 3° 42′ N
	Batavia	21-07-19	2110	O = 21-07-28	λ = 98° 49′ E
	Belgrade	21-07-32	8410		
	Budapest	21-07-41	8540		Pulkovo gives
	Irkutsk	21-07-16	6300		ϕ = 1° 1′ N
	Leningrad	21-07-31	8470		λ = 93° 46′ E
	Ekaterinburg	21-07-24	7040		
	Hamburg	21-07-26	9450		Strasbourg gives
	Jinsen	21-07-24	5810		ϕ = 0° N
	Kucino	21-07-29	7860		λ = 87° E
	Piatigorsk	21-07-16	6920		
	Osaka	21-07-37	6300		
	Paris	21-07-35	9700		Makéevka gives
	Perth	21-07-40	4080		ϕ = 4°·5′ N
	Hohenheim	21-07-38	9230		λ = 98° 25′ E
	Pulkovo	21-07-33	8450		
	Strasbourg	21-07-27	9470		
	Uccle	21-07-34	9580		
	Wien	21-07-29	8850		
	Zi-ka-wei	21-07-19	5040		
	Zürich	21-07-43	9080		
	Toledo	21-07-26	10220		
	Almeria	21-07-16	10320		
	Agram	21-07-31	8800		
	Graz	21-07-29	8820		
	Taihoku	21-07-22	4720		
	Firenze	21-07-37	9000		
	Makéevka	21-07-23	7460		
	Baku	21-07-17	6250		
	Alicante	21-07-14	10330		
	Malaga	21-07-16	10100		
Jan. 25	Ottawa	0-36-21	13110	ϕ = 10° S	Strasbourg gives
2336	Batavia	0-35-59	6000	λ = 162° E	ϕ = 10° S
	Berkeley	0-36-42	9350	O = 0-36-14	λ = 158°·5 E
	Irkutsk	0-36-16	8800		
	Fordham	0-36-23	13400		
	Jinsen	0-36-17	6230		
	Lick	0-36-28	9560		
	Osaka	0-35-56	5750		
	Perth	0-36-06	5240		
	Nogoya	0-36-03	5530		
	Pulkovo	0-36-24	12650		
	Victoria	0-36-55	9300		
	Zi-ka-wei	0-36-22	6050		
	Santa Clara	0-36-00	9880		
	Sucre	0-36-23	14140		
	Sydney	0-35-43	2900		
	Nagasaki	0-36-17	5620		
	Taihoku	0-35-49	5850		
	Kobe	0-36-17	5520		
	Toyooka	0-36-05	5750		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Jan. 26	Batavia	7–04–39	6900	ϕ = 21° S	
2337	Sydney	7–04–14	2360	λ = 170° E	
	Wellington	7–04–33	2260	O = 7–04–29	
	Apia	7–04–27	2270		
	Irkutsk	7–04–32	10260		
Feb. 6	Ekaterinburg	8–49–45	5800	ϕ = 42° N	
2346	Irkutsk	8–49–51	3070	λ = 143° E	
	Baku	8–49–43	7700	O = 8–49–46	
Feb. 7	Ekaterinburg	22–41–55	6950	ϕ = 51° N	Ekaterinburg gives
2349	Pulkovo	22–42–03	7450	λ = 178° W	ϕ = 50° 40′ N
	Baku	22–42–09	8850	O = 22–42–02	λ = 183° 2′ E.
Feb. 8	Ottawa	15–17–37	3900	ϕ = 12° N	Spokane gives
2350	Algiers	15–18–23	9010	λ = 88°·5 W	ϕ = 11° N
	Berkeley	15–17–51	4220	O = 15–17–38	λ = 87° W
	Almeria	15–18–09	8780		
	Malaga	15–17–27	9020		
	Fordham	15–17–17	3650		
	Georgetown	15–17–15	3360		
	Hamburg	15–17–44	9620		
	Innsbruck	15–16·9	10350		
	Ithaca	15–17–44	3520		
	LaPaz	15–17–28	4150		
	Toledo	15–17–17	9100		
	Lick	15–17–40	4320		
	Hohenheim	15–18–15	9350		
	Pulkovo	15–18–14	9690		
	San Fernando	15–18–12	8470		
	Strasbourg	15–17–42	9690		
	Toronto	15–17–19	3700		
	Uccle	15–17–52	9150		
	Victoria	15–17–47	5120		
	Santa Clara	15–18–37	4370		
	St. Louis	15–17–30	2950		
	New Orleans	15–17–31	2150		
	Sucre	15–17–39	4280		
	Spokane	15–16–51	5150		
Feb. 9	Ottawa	0–24–24	7200	ϕ = 17° S	Sucre gives
2351	Algiers	0–24–40	8260	λ = 57° W	ϕ = 26°·2 S
	LaPaz	0–24–39	1160	O = 0–24–27	λ = 66° W
	Toronto	0–24–15	7180	Location	
	Zürich	0–24–17	9560	approximate	
	Sucre	0–24–41	890		
	Malaga	0–24–12	8400		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Feb. 15	Ottawa............	2-59-49	3700	ϕ = 13° N	Science Service gives
2356	Algiers............	2-59-49	9320	λ = 86°·5 W	ϕ = 12° N
	Barcelona..........	2-59-18	9410	O = 2-59-50	λ = 89° W
	Berkeley...........	2-59-48	4220		
	Budapest...........	3-00-11	9680		Pulkovo gives
	Toledo.............	2-59-55	8680		ϕ = 10° 55′ N
	Almeria............	2-59-59	8750		λ = 92° 1′ W
	Fordham...........	2-59-44	3330		
	Georgetown.........	2-59-45	3100		Strasbourg gives
	Hamburg...........	3-00-12	9160		ϕ = 14°·5 N
	Ithaca.............	2-59-49	3360		λ = 86°·5 W
	LaPaz..............	2-59-36	3820		
	Malaga.............	2-59-46	8800		Zürich gives
	Alicante...........	2-59-54	8750		ϕ = 15° N
	Hohenheim.........	3-00-04	9280		λ = 90° W
	Paris..............	3-00-00	8940		
	Leningrad.........	2-59-32	10670		Sucre gives
	San Fernando.......	2-59-58	8550		ϕ = 11°·3 N
	Strasbourg.........	2-59-56	9340		λ = 88°·8 W
	Toronto............	2-59-49	3420		
	Uccle..............	2-59-55	9060		
	Victoria...........	2-59-30	5230		
	Wien..............	2-59-47	10050		
	Zürich.............	3-00-03	9300		
	Halifax............	2-59-51	4180		
	La Plata...........	2-59·7	6110		
	St. Louis..........	2-59-41	2840		
	New Orleans........	2-59-26	2035		
	Sucre..............	2-59-30	4320		
	Graz...............	3-00-13	9350		
	Firenze............	3-00-12	9350		
	Ste. Anne..........	2-59-48	4140		
Mar. 1	Algiers............	20-01-46	2360	ϕ = 37° N	Strasbourg gives
2369	Barcelona..........	20-01-29	2580	λ = 29° E	ϕ = 37° N
	Toledo.............	20-01-51	2850	O = 20-01-47	λ = 28° E
	Almeria............	20-01-42	2890		
	Ekaterinburg.......	20-01-48	3070		Zürich gives
	Hamburg...........	20-01-45	2400		ϕ = 37° N
	Piatigorsk.........	20-01-50	1470		λ = 31° E
	Paris..............	20-01-46	2540		
	Pulkovo............	20-01-37	2610		
	Strasbourg.........	20-01-46	2220		
	Uccle..............	20-01-42	2560		
	Zürich.............	20-01-50	2080		
	Ksara..............	20-01-59	710		
	München...........	20-01-47	1990		
	Graz...............	20-02-02	1540		
	Kucino.............	20-01-57	2160		
	Leningrad.........	20-01-45	2570		
	Baku...............	20-02-02	1830		
	Ravensburg.........	20-01-33	2160		
	Hohenheim.........	20-01-48	2120		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Mar. 4	Batavia	9-31-46	2640	ϕ = 6° N	Ekaterinburg gives
2370	Piatigorsk	9-31-07	9000	λ = 127°·5 E	ϕ = 5° 23′ N
	Wellington	9-31-40	6450	O = 9-31-05	λ = 127° 5′ E
	Ekaterinburg	9-31-03	8090		
	Osaka	9-30-53	3250		Irkutsk gives
	Pulkovo	9-30-51	10030		ϕ = 8° N
	Baku	9-31-02	8640		λ = 133° E
	Makéevka	9-30-46	9950		
	Irkutsk	9-30-54	5560		
	Leningrad	9-30-56	9980		
Mar. 7	Ottawa	20-33-30	5400	ϕ = 2° S	
2373	Ithaca	20-33-20	5200	λ = 71° W	
	LaPaz	20-33-25	1610	O = 20-33-28	
	Toronto	20-33-31	5160	Location doubtful.	
	La Plata	20-33-34	3660		
Mar. 8	Ekaterinburg	20-21-28	6050	ϕ = 43° N.	Ekaterinburg gives
2374	Pulkovo	20-21-38	7300	λ = 150° E	ϕ = 42° 6′ N
	Baku	20-21-38	7760	O = 20-21-40	λ = 148° 3′ E
	Piatigorsk	20-21-51	7760		
	Leningrad	20-21-37	7320		Itkutsk gives
	Kucino	20-21-41	7240		ϕ = 43°·7 N
	Jinsen	20-21-52	1820		λ = 146°·6 E
					Pulkovo gives
					ϕ = 43° 46′ N
					λ = 149° 41′ E
Mar. 11	Ottawa	10-41-48	6250	ϕ = 13° S	LaPaz gives
2376	LaPaz	10-42-15	860	λ = 76° W	ϕ = 13°·7 S
	Toronto	10-41-20	6500	O = 10-41-50	λ = 76°·6 W
	Sucre	10-42-17	1230	Location approximate	

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Mar. 17	Ottawa............	11-53-38	3530	ϕ = 12° N	St. Louis gives
2381	Algiers............	11-53-44	8720	λ = 82° W	ϕ = 11° N
	Toledo............	11-53-28	8360	O = 11-53-37	λ = 82° W
	Almeria............	11-53-48	8250		
	Fordham............	11-53-39	3140		LaPaz gives
	Georgetown.........	11-53-28	2970		ϕ = 9°.4 N
	Hamburg............	11-53-47	8980		λ = 85° W
	Innsbruck..........	11-53-50	9100		
	Ithaca............	11-53-37	3230		Strasbourg gives
	LaPaz............	11-53-52	3240		ϕ = 13° N
	Firenze............	11-53-17	9600		λ = 78° W
	Leningrad..........	11-53-26	10200		
	Paris............	11-53-40	8620		
	Hohenheim..........	11-53-47	9000		
	San Fernando.......	11-53-39	8160		
	Strasbourg.........	11-53-22	9280		
	Toronto............	11-53-40	3240		
	Uccle............	11-53-33	8850		
	Victoria...........	11-53-19	5510		
	Wien............	11-53-36	9560		
	St. Louis..........	11-53-06	3110		
	Rocca di Papa......	11-53-36	9620		
	Denver............	11-54-04	3700		
	Zagreb............	11-53-45	9600		
	New Orleans........	11-53-30	2170		
	Graz............	11-53-44	9450		
	Sucre............	11-53-34	3840		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Mar. 18	Ottawa	14–06–27	8320	ϕ = 36° N	St. Louis gives
2382	Algiers	14–05–42	2600	λ = 31°·2 E	ϕ = 36° N
	Barcelona	14–06–02	2540	O = 14–06–03	λ = 30° E
	Baku	14–06–11	1860		
	Budapest	14–05–58	1650		
	Jinsen	14–06–12	8120		Ekaterinburg gives
	Irkutsk	14–06–16	5750		ϕ = 36° 46′ N
	Ekaterinburg	14–06–06	3170		λ = 30° 10′ E
	Fordham	14–06–00	8750		
	Firenze	14–06–02	1870		
	Georgetown	14–06–31	8800		Leningrad gives
	Hamburg	14–05–57	2550		ϕ = 36° N
	Innsbruck	14–06–07	2000		λ = 30° 18′ E
	Ithaca	14–06–42	8220		
	LaPaz	14–06–28	11980		Makéevka gives
	Lemberg	14–05·9	1750		ϕ = 36° 20′ N
	Leningrad	14–05–54	2720		λ = 27° 50′ E
	Makéevka	14–06–03	1540		
	Toledo	14–05–47	3040		Strasbourg gives
	Piatigorsk	14–06–27	1410		ϕ = 36° N
	Paris	14–05–43	2800		λ = 29° E
	Alicante	14–06–17	2750		
	Pulkovo	14–06–13	2220		
	San Fernando	14–06–08	3240		Zürich gives
	Strasbourg	14–05–38	2510		ϕ = 36° N
	Toronto	14–06–24	8680		λ = 29° E
	Ravensburg	14–05–44	2360		
	Hohenheim	14–05–45	2400		
	Uccle	14–05–50	2700		
	Wien	14–05–41	2000		
	Zürich	14–06–05	2160		
	Halifax	14–06–31	7450		
	St. Louis	14–06–43	9280		
	Rocca di Papa	14–05–51	1750		
	Zagreb	14–06–21	1480		
	Graz	14–05–54	1840		
	Sucre	14–06–35	11770		
Mar. 24	Pulkovo	7–04–26	2620	ϕ = 33° N	
2391	Strasbourg	7–04–16	2350	λ = 27°·5 E	
	Uccle	7–04–44	2460	O = 7–04–23	
	Rocca di Papa	7–04–22	1610		
	Graz	7–04–10	1910		
	Firenze	7–04–15	1850		
	Zürich	7–04–31	2090		
	Leningrad	7–04–23	2650		
Mar. 27	Irkutsk	10–48–39	8470	ϕ = 7°·5 S	Ekaterinburg gives
2398	Ekaterinburg	10–48–44	10900	λ = 157° E	ϕ = 6° 47′ S
	Osaka	10–48–46	5200	O = 10–48–40	λ = 155° 6′ E
	Perth	10–48–41	4860		
	Apia	10–48–26	3470		
	Jinsen	10–48–31	6050		
	Taihoku	10–48–52	5160		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
April 1	Leningrad..........	16-03-44	7140	ϕ = 39° N	Irkutsk gives
2401	Irkutsk..........	16-03-52	2770	λ = 134° E	ϕ = 38° N
	Hamburg..........	16-03-54	8360	O = 16-03-50	λ = 133°·4 E
	Makéevka..........	16-03-55	7240		
	Baku..........	16-03-46	6920		Ekaterinburg gives
	Pulkovo..........	16-03-44	7140		ϕ = 41° 8′ N
	Strasbourg..........	16-03-51	8820		λ = 137° 20′ E
	Uccle..........	16-03-54	8740		
	Wien..........	16-03-50	8480		
	Zi-ka-wei..........	16-03-50	1400		
	Zagreb..........	16-03-56	8620		
April 5	Algiers..........	23-28-44	3000	ϕ = 40° N	Strasbourg gives
2404	Barcelona..........	23-28-52	2800	λ = 30° W	ϕ = 40° N
	Leningrad..........	23-29-20	4560	O = 23-29-15	λ = 27° W
	Irkutsk..........	23-29-19	8940		
	Ekaterinburg..........	23-29-15	6540		
	Hamburg..........	23-29-31	3140		
	LaPaz..........	23-29-26	7340		
	Makéevka..........	23-29-24	5210		
	Baku..........	23-29-35	6450		
	Paris..........	23-29-23	2640		
	Pulkovo..........	23-29-10	4650		
	San Fernando..........	23-28-54	2200		
	Strasbourg..........	23-29-26	2950		
	Uccle..........	23-29-31	2690		
	Agram..........	23-29-36	3450		
	Sucre..........	23-29-20	7490		
	Toledo..........	23-28-56	2300		
	Malaga..........	23-28-51	2360		
April 6	Leningrad..........	19-32-27	7250	ϕ = 43° N	Irkutsk gives
2405	Irkutsk..........	19-32-24	3010	λ = 148° E	ϕ = 44°·8 N
	Ekaterinburg	19-32-23	5840	O = 19-32-13	λ = 144°·2 E
	Baku..........	19-31-54	8120	Location approximate	
	Pulkovo..........	19-32-25	7240		
	Zi-ka-wei..........	19-31-45	2620		
April 12	Ekaterinburg..........	8-32-35	11220	ϕ = 10° S	Ekaterinburg gives
2413	Irkutsk..........	8-32-31	8790	λ = 165° E	ϕ = 3°·1 S
	Manila..........	8-31-56	5660	O = 8-32-20	λ = 166°·0 E
	Osaka..........	8-32-16	5840	Location approximate	
	Wellington..........	8-32-35	3350		Irkutsk gives
	Sydney Observatory.	8-32-14	2820		ϕ = 6°·0 S
	Taihoku..........	8-32-11	5950		λ = 167°·8 E
	Toyooka..........	8-32-15	5870		
	Jinsen..........	8-32-19	6500		
April 22	Leningrad..........	23-48-09	8850	ϕ = 25° N	
2419	Irkutsk..........	23-47-56	4520	λ = 145°·5 E	
	Baku	23-48-02	8700	O = 23-48-01	
	Pulkovo..........	23-48-09	8880		
	Zi-ka-wei..........	23-47-51	2410		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
April 28	Ottawa	11-13-43	7420	ϕ = 20° S	
2426	Algiers	11-14-11	9150	λ = 62° W	
	Toledo	11-14-00	9090	O = 11-13-47	
	Malaga	11-13-58	8950	Location approximate	
	Fordham	11-13-51	6750		
	Georgetown	11-14-00	6550		
	Innsbruck	11-14-06	10320		
	Ithaca	11-13-50	7050		
	LaPaz	11-13-17	940		
	Alicante	11-13-37	9600		
	San Fernando	11-13-56	8900		
	Toronto	11-13-39	7280		
	Victoria	11-13-43	9230		
	Zürich	11-13-50	10380		
	Halifax	11-13-42	7250		
	St. Louis	11-13-43	6980		
	Spokane	11-13-41	9150		
	La Plata	11-13·4	1810		
May 5	Ottawa	6-21-21	4960	ϕ = 2°·8 N	Sucre gives
2430	Fordham	6-21-23	4520	λ = 89°·8 W	ϕ = 6°·4 S
	Georgetown	6-21-19	4220	O = 6-21-27	λ = 87°·0 W
	LaPaz	6-21-31	3200		
	Rio de Janeiro	6-21·4	5500		
	Toronto	6-21-24	4630		
	Sucre	6-21-22	3700		
	Toledo	6-21-39	9480		
	Malaga	6-21-37	9420		
May 7	Baku	6-11-17	8120	ϕ = 32°·5 N	
2431	Ekaterinburg	6-11-20	6620	λ = 144° E	
	Hamburg	6-11-35	9200	O = 6-11-25	
	Kucino	6-11-37	7820		
	Irkutsk	6-11-32	3410		
	Pulkovo	6-11-24	8070		
	Wien	6-11-20	9650		
	Zi-ka-wei	6-11-04	2080		
	Leningrad	6-11-26	8050		
	Piatigorsk	6-11-36	7890		
May 12	Ekaterinburg	14-53-39	8640	ϕ = 45° N	
2435	Irkutsk	14-53-19	8250	λ = 125° W	
	Pulkovo	14-53-36	8190	O = 14-53-30	
May 20	Batavia	7-02-18	2320	ϕ = 5° N	
2440	Ekaterinburg	7-02-21	7890	λ = 125° E	
	Makéevka	7-02-23	9120	O = 7-02-12	
	Baku	7-02-17	8370		
	Pulkovo	7-02-24	9440		
	Zi-ka-wei	7-01-45	3070		
	Taihoku	7-02-09	2210		
	Piatigorsk	7-01-56	9220		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
May 26	Algiers	19–45–10	9940	ϕ = 41°·8 N	Makéevka gives
2445	Makéevka	19–44–57	7670	λ = 142°·2 E	ϕ = 34°·9 N
	Baku	19–45–07	7300	O = 19–45–03	λ = 134° E
	Ekaterinburg	19–45–01	5740		
	Hamburg	19–45–08	8450		Ekaterinburg gives
	Irkutsk	19–44–55	2980		ϕ = 38° 35′ N
	Kucino	19–45–00	7050		λ = 137° 16′ E
	Leningrad	19–45–02	7180		
	Paris	19–45–08	9150		Irkutsk gives
	Pulkovo	19–45–03	7140		ϕ = 45°·1 N
	Zi-ka-wei	19–44–59	2150		λ = 144°·0 E
	Zürich	19–45–06	9070		
					Pulkovo gives
					ϕ = 44° 48′ N
					λ = 149° 26′ E
May 31	Algiers	13–35–52	9600	ϕ = 35° S	
2449	Barcelona	13–35–53	10050	λ = 55° E	
	Baku	13–35–50	8380	O = 13–35–53	
	Leningrad	13–35–54	10480	Location approximate	
	Ekaterinburg	13–35–58	9900		
	Helwan	13–35–52	7660		
	Kucino	13–35–51	10000		
	Makéevka	13–36–02	9160		
	Pulkovo	13–35–55	10430		
	Strasbourg	13–35–54	10230		
	Wien	13–35–49	9950		
	Firenze	13–35–51	10100		
	Agram	13–35–55	9820		
	Malaga	13–35–39	10350		
	Alicante	13–35–43	10180		
	Wellington	13–36–05	9200		
	Piatigorsk	13–35–53	8740		
	Moncalieri	13–36–09	9820		
June 3	Irkutsk	4–47–02	9400	ϕ = 13° S	Irkutsk gives
2452	Osaka	4–47–08	6350	λ = 170° E	ϕ = 11°·1 S
	Victoria	4–47–02	9600	O = 4–47–07	λ = 168°·6 E
	Apia	4–47–32	1860	Location approximate	
	Wellington	4–46–52	2840		Apia gives
					ϕ = 17° S
					λ = 170° E
June 4	Irkutsk	6–50–54	2280	ϕ = 35°·2 N	Irkutsk gives
2454	Makéevka	6–50–57	4320	λ = 88°·5 E	ϕ = 35°·8 N
	Ekaterinburg	6–50–59	3110	O = 6–50–48	λ = 89°·1 E
	Zi-ka-wei	6–50–21	3270		
	Baku	6–50–48	3470		Ekaterinburg gives
					ϕ = 35° 56′ N
					λ = 88° 22′ E
June 4	Ekaterinburg	15–07–21	5740	ϕ = 42° N	Ekaterinburg gives
2455	Makéevka	15–07–21	7650	λ = 144° E	ϕ = 31° 19′ N
	Pulkovo	15–07–22	7120	O = 15–07–22	λ = 127° 12′ E
	Baku	15–07–18	7450		
	Leningrad	15–07–27	7050		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
June 5	Berkeley	19–50–17	800	ϕ = 43°·2 N	
2457	Ekaterinburg	19–50–33	8880	λ = 129°·2 W	
	Georgetown	19–50–14	4250	O = 19–50–25	
	Hamburg	19–50–33	8600		
	Makéevka	19–50–33	9750		
	Lick	19–50–24	875		
	Paris	19–50–35	8400		
	Strasbourg	19–50–39	8920		
	Saskatoon	19–50–13	1900		
	Denver	19–50–01	1670		
	Spokane	19–50–22	850		
	Malaga	19–50–23	9560		
	Alicante	19–50–23	9650		
	Leningrad	19–50–38	8370		
June 21	Irkutsk	8–49–10	3500	ϕ = 31° N	
2466	Ekaterinburg	8–48–56	6680	λ = 142° E	
	Makéevka	8–49–01	8440	O = 8–48–58	
	Pulkovo	8–48–59	8200		
	Strasbourg	8–48–59	9980		
	Zi-ka-wei	8–48–53	1950		
	Baku	8–48–48	8160		
June 26	Ottawa	19–46–47	7900	ϕ = 35°·5 N	Irkutsk gives
2471	Algiers	19–46–25	2160	λ = 27°·5 E	ϕ = 37°·4 N
	Barcelona	19–46–00	2450	O = 19–46–31	λ = 29°·3 E
	Batavia	19–46–21	9650		
	Belgrade	19–46–31	1150		Strasbourg gives
	Almeria	19–46–13	2730		ϕ = 36° N
	Fordham	19–46–45	7980		λ = 27°·5 E
	Georgetown	19–46–29	8600		
	Hamburg	19–46–25	2290		Uccle gives
	Halifax	19–46–35	7220		ϕ = 35°·5 N
	Hohenheim	19–46–41	1880		λ = 27°·6 E
	Ithaca	19–46–48	8150		
	Paris	19–46–13	2510		Leningrad gives
	Pulkovo	19–46–21	2590		ϕ = 36° 22′ N
	San Fernando	19–46–30	2880		λ = 26° 19′ E
	Irkutsk	19–46–37	5870		
	Strasbourg	19–46–19	2150		
	Toronto	19–46–33	8380		
	Uccle	19–46–04	2560		
	Victoria	19–47–11	9220		
	Wien	19–47–09	1260		
	Zürich	19–46–19	2040		
	Leningrad	19–46–22	2600		
	Saskatoon	19–47–04	8720		
	St. Louis	19–46–56	9000		
	Agram	19–46–24	1600		
	Firenze	19–46–06	1800		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
June 28 2473	Batavia	3-23-21	930	ϕ = 0°	Pulkovo gives
	Budapest	3-23-43	9200	λ = 101° E	ϕ = 2° 6′ S
	Irkutsk	3-23-05	6180	O = 3-23-32	λ = 96° 18′ E
	Ekaterinburg	3-23-28	7240		
	Makéevka	3-23-38	7880		
	Osaka	3-23-34	5200		
	Pulkovo	3-23-31	8900		
	Strasbourg	3-23-50	9690		
	Wien	3-23-24	9650		
	Agram	3-23-35	9500		
	Ravensburg	3-23-54	9510		
	Baku	3-23-25	6890		
	Leningrad	3-23-31	8900		
June 28 2474	Budapest	6-15-56	9200	ϕ = 1° S	Ekaterinburg gives
	Irkutsk	6-15-28	5930	λ = 99°·5 E	ϕ = 0° 53′ N
	Ekaterinburg	6-15-40	7280	O = 6-15-45	λ = 102° 32′ E
	Makéevka	6-15-50	7960		
	Osaka	6-15-39	5350		Pulkovo gives
	Pulkovo	6-15-49	8850		ϕ = 4° 17′ S
	Wien	6-15-38	9680		λ = 91° 4′ E
	Agram	6-16-08	9330		
	Baku	6-15-39	6850		
	Leningrad	6-15-49	8880		
June 29 2475	Batavia	14-27-17	3740	ϕ = 29° N.	Zürich gives
	Belgrade	14-26-55	9060	λ = 128° E	ϕ = 40° N
	Budapest	14-27-07	8800	O = 14-27-07	λ = 140° E
	Ekaterinburg	14-26-53	5950		
	Hamburg	14-27-01	9020		
	Innsbruck	14-27-13	9100		
	Lemberg	14-27·2	8320		
	Leningrad	14-27-02	7650		
	Piatigorsk	14-27-05	7390		
	Manila	14-26-52	1560		
	Paris	14-27-23	9230		
	Pulkovo	14-27-00	7650		
	Irkutsk	14-27-30	2750		
	Baku	14-26-53	7010		
	Strasbourg	14-27-12	9150		
	Wellington	14-26-54	8820		
	Uccle	14-27-11	9220		
	Victoria	14-27-04	8840		
	Wien	14-26-57	9080		
	Zürich	14-27-18	9100		
	Agram	14-27-06	9060		
	Firenze	14-27-10	9300		
	Bergen	14-26-58	8800		
	Jinsen	14-27-11	1050		
	Kobe	14-27-19	950		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
June 30	Irkutsk	22–52–13	2850	ϕ = 38°·5 N	Ekaterinburg gives
2480	Ekaterinburg	22–51–43	2170	λ = 72° E	ϕ = 39° 12′ N
	Pulkovo	22–51–44	3530	O = 22–51–45	λ = 70° 58′ E
	Baku	22–51–32	1890		
	Leningrad	22–51–45	3550		
July 1	Budapest	14–09–08	9400	ϕ = 3° S	Pulkovo gives
2481	Ekaterinburg	14–08–50	7530	λ = 101° E	ϕ = 6° 37′ S
	Helwan	14–09–01	8300	O = 14–08–54	λ = 95° 48′ E
	Irkutsk	14–08–46	6110	Location approximate	
	Piatigorsk	14–09–09	7500		Strasbourg gives
	Leningrad	14–08–50	9280		ϕ = 8°·5 N
	Kucino	14–08–38	8780		λ = 93°·5 E
	Pulkovo	14–08–46	9320		
	Uccle	14–09–11	10350		
	Wien	14–08–38	10050		
	Jinsen	14–08–37	5240		
	Graz	14–09–06	9770		
	Firenze	14–08–55	10050		
	Malaga	14–09–02	11760		
July 1	Ottawa	20–29–39	5580	ϕ = 4°·8 S	Sucre gives
2482	Cartuja	20–29–34	9500	λ = 81°·5 W	ϕ = 16° S
	LaPaz	20–29–32	1970	O = 20–29–37	λ = 88° W
	Toronto	20–29–39	5350		
	Victoria	20–29–55	7110		
	La Plata	20–29·5	3910		
	Sucre	20–29–21	2450		
	Almeria	20–29–49	9400		
July 6	Ekaterinburg	21–20–34	5640	ϕ = 12°·5 N	
2489	Pulkovo	21–20–38	7350	λ = 94° E	
	Leningrad	21–20–38	7380	O = 21–20–35	
	Irkutsk	21–20–32	4520		
July 9	Barcelona	15–05–12	2880	ϕ = 38° N	
2491	Cartuja	15–05–37	2290	λ = 30° W	
	Pulkovo	15–05–34	4690	O = 15–05–30	
	Toledo	15–05–32	2250	Location approximate	
	Almeria	15–05–41	2180		
	Malaga	15–05–26	2320		
	Alicante	15–05–26	2380		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
July 10 2495	Batavia............ Baku............... Osaka.............. Pulkovo............ Mizusawa.......... Apia............... Piatigorsk......... Kucino............. Leningrad.......... Irkutsk............	10–51–05 10–51–13 10–51–06 10–51–12 10–51–08 10–51–05 10–51–21 10–51–17 10–51–11 10–51–06	2260 8750 3920 10050 4380 7400 9150 9630 10150 6020	ϕ = 1° N λ = 126° E O = 10–51–10	
July 12 2498	Ekaterinburg....... Irkutsk............ Baku...............	16–51–44 16–51–34 16–51–35	8360 6030 8820	ϕ = 1°·5 N λ = 126°·5 E O = 16–51–37	
July 14 2505	Ekaterinburg....... Pulkovo............ Leningrad.......... Irkutsk............ Baku...............	22–22–21 22–22–19 22–22–25 22–22–31 22–22–31	5850 5950 5870 4780 7850	ϕ = 66° N λ = 166° W O = 22–22–25	
July 15 2506	Ekaterinburg....... Pulkovo............ Baku...............	21–47–10 21–47–26 21–47–09	6140 7830 6980	ϕ = 25°·5 N λ = 125° E O = 21–47–15	
July 16 2507	Ekaterinburg....... Osaka.............. Perth.............. Sydney Observatory.	2–05–03 2–04–45 2–05–33 2–05–30	9600 4500 4890 3400	ϕ = 4° S λ = 150° E O = 2–05–12 Location approximate	
July 23 2516	Batavia............ Ekaterinburg....... Pulkovo............ Zi-ka-wei.......... Irkutsk............ Baku............... Leningrad..........	5–16–32 5–16–57 5–17–00 5–16–39 5–16–53 5–17–01 5–16–58	2640 7880 9500 2810 5320 8360 9520	ϕ = 7° N λ = 127° E O = 5–16–51	Irkutsk gives ϕ = 9°·6 N λ = 129°·2 E

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
July 26 2522	Ekaterinburg........	18–54–55	5240	ϕ = 40° N	Irkutsk gives
	Osaka..............	18–54–58	275	λ = 133°·5 E	ϕ = 47°·3 N
	Strasbourg..........	18–54–54	8580	O = 18–54–49	λ = 126°·5 E
	Uccle..............	18–54–51	8550		
	Zi-ka-wei...........	18–54–44	1350		
	Irkutsk............	18–54–47	2650		
	Leningrad..........	18–54–46	6890		
	Zürich.............	18–54–38	8720		
July 27 2524	Ekaterinburg........	7–23–44	3270	ϕ = 29°·5 N	Ekaterinburg gives
	Pulkovo............	7–23–39	4960	λ = 78°·5 E	ϕ = 30° 51′ N
	Leningrad..........	7–23–39	4960	O = 7–23–32	λ = 80° 29′ E
	Irkutsk............	7–23–05	3420		
July 28 2525	Osaka..............	8–52–12	6020	ϕ = 9° S	
	Victoria............	8–52–13	10050	λ = 156° E	
	Zi-ka-wei...........	8–52–21	5750	O = 8–52–12	
	Apia...............	8–51–51	3600		
	Irkutsk............	8–52–22	8470		
July 31 2530	Ekaterinburg........	18–09–40	7350	ϕ = 36° N	
	Pulkovo............	18–09–45	5370	λ = 37° W	
	San Fernando.......	18–09–41	2750	O = 18–09–42	
	Strasbourg..........	18–09–41	3750	Location approximate	
	Uccle..............	18–09–49	3480		
	Zürich.............	18–09–25	3950		
	Baku...............	18–09–53	7330		
Aug. 2 2532	Budapest...........	5–01·4	10050	ϕ = 16°·5 N	Pulkovo gives
	Baku...............	5–01–28	7880	λ = 129° E	ϕ = 18° 26′ N
	Ekaterinburg........	5–01–33	7150	O = 5–01–32	λ = 132° 6′ E
	Helwan.............	5–01–42	9340		
	Lemberg............	5–00·1	10320		
	Pulkovo............	5–01–36	8880		
	Leningrad..........	5–01–36	8910		
	Victoria............	5–02–21	9440		
	Wien...............	5–01–44	9940		
	Zi-ka-wei...........	5–01–34	1950		
	Piatigorsk..........	5–01–15	8150		
	Jinsen.............	5–01–40	2530		
	Makéevka..........	5–01–53	8290		
	Taihoku............	5–01–39	1230		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 2	Ekaterinburg........	12-41-12	7180	ϕ = 17° N	Ekaterinburg gives
2533	Pulkovo..........	12-41-21	8820	λ = 130° E	ϕ = 14° 33′ N
	Zi-ka-wei	12-40-55	2100	O = 12-41-11	λ = 125° 21′ E
	Makéevka..........	12-41-14	8620	Location approximate	
	Leningrad..........	12-41-22	8840		
	Baku..............	12-41-04	7950		
Aug. 3	Budapest..........	3-41-30	9300	ϕ = 22°·7 N	Pulkovo gives
2534	Baku..............	3-41-31	7100	λ = 124° E	ϕ = 19°·8 N
	Ekaterinburg........	3-41-36	6220	O = 3-41-34	λ = 119°·1 E
	Hamburg..........	3-41-40	9340		
	Manila............	3-41-07	970		Leningrad gives
	Naples............	3-42-01	9400		ϕ = 22° 42′ N
	Pulkovo..........	3-41-37	8050		λ = 125° 57′ E
	Strasbourg..........	3-41-34	9830		
	Uccle..............	3-41-59	9440		
	Wien..............	3-41-29	9440		
	Zi-ka-wei..........	3-41-22	1130		
	Mizusawa..........	3-41-37	2560		
	Leningrad..........	3-41-38	8050		
	Piatigorsk..........	3-41-23	7400		
	Irkutsk............	3-41-23	3620		
	Makéevka..........	3-41-35	7820		
	Firenze............	3-41-37	9820		
	Graz..............	3-42-04	9080		
	Hohenheim..........	3-40-53	10220		
	Agram............	3-41-45	8300		
Aug. 3	Baku..............	10-32-09	9070	ϕ = 1° N	Ekaterinburg gives
2535	Ekaterinburg........	10-32-17	8650	λ = 130° E	ϕ = 2° 49′ S
	Manila............	10-31-48	2150	O = 10-32-00	λ = 122° 41′ E
	Osaka..............	10-32-36	3660	Location approximate	
	Perth..............	10-31-11	3880		
	Mizusawa..........	10-31-48	4880		
	Zi-ka-wei..........	10-32-08	3500		
	Sumoto............	10-32-18	3920		
	Wellington..........	10-31-59	6450		
	Makéevka..........	10-31-39	10550		
	Irkutsk............	10-32-00	6450		
	Piatigorsk..........	10-31-58	9280		
	Leningrad..........	10-32-11	10400		
Aug. 6	Cartuja............	15-51-46	11120	ϕ = 19° N	Pulkovo gives
2538	Paris..............	15-52-39	9420	λ = 118° E	ϕ = 23° 27′ N
	Pulkovo............	15-52-12	7920	O = 15-51·8	λ = 123° 15′ E
	Uccle..............	15-52-38	9300	Location doubtful	
	Zi-ka-wei..........	15-51-22	1280		
	Makéevka..........	15-52-12	7760		
	Irkutsk............	15-51-20	3920		
	Zürich............	15-51-26	9440		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 6	Cartuja	22–45–57	7110	ϕ = 35° N	Pulkovo gives
2540	Ekaterinburg	22–45–50	2680	λ = 77°·5 E	ϕ = 35° 54′ N
	Hamburg	22–45–59	5440	O = 22–45–52	λ = 77° 58′ E
	Paris	22–45–53	6200		
	Pulkovo	22–45–48	4280		Irkutsk gives
	Strasbourg	22–45–55	5750		ϕ = 36°·0 N
	Uccle	22–45–53	5990		λ = 77°·6 E
	Agram	22–45–50	5240		
	Firenze	22–45–57	5700		Leningrad gives
	Moncalieri	22–46–08	5700		ϕ = 38° 22′ N
	Makéevka	22–45–56	3420		λ = 80° 30′ E
	Irkutsk	22–45–32	2850		
	Toledo	22–45–49	7110		
	Almeria	22–45–42	7210		
	Malaga	22–45–51	7300		
	Leningrad	22–45–54	4220		
Aug. 9	Ottawa	3–39–30	6620	ϕ = 51°·7 N	St. Louis gives
2543	Ekaterinburg	3–39–22	6980	λ = 173°·5 W	ϕ = 52° N
	Cartuja	3–39–30	10000	O = 3–29–26	λ = 176° W
	Fordham	3–39–24	7340		
	Ithaca	3–39–19	7080		
	Paris	3–39–35	8820		
	Pulkovo	3–39–22	7530		
	Moncalieri	3–39–20	9300		
	Toronto	3–39–27	6640		
	Victoria	3–39–23	3470		
	Uccle	3–39–27	8680		
	Zürich	3–39–35	8880		
	St. Louis	3–39–34	6350		
	Spokane	3–39–09	3850		
	Makéevka	3–39–31	8520		
	Leningrad	3–39–24	7450		
Aug. 17	Belgrade	1–42–42	980	ϕ = 37° N	Pulkovo gives
2557	Cartuja	1–42–35	1700	λ = 16° E	ϕ = 38°·8 N
	Naples	1–41–55	680	O = 1–42·4	λ = 15°·4 E
	Paris	1–42–18	1760	Location approximate	
	Pulkovo	1–42–42	2550		
	Graz	1–41–33	1500		
	Makéevka	1–42–54	2090		
	Almeria	1–42–35	1630		
	Malaga	1–41–52	1680		
	Leningrad	1–42–43	2540		
	Moncalieri	1–42–57	880		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 30	Ottawa	11-38-23	7480	ϕ = 37°N	Leningrad gives
2567	Algiers	11-38-10	1710	λ = 24°·5E	ϕ = 38° 23′ N
	Barcelona	11-38-02	1870	O = 11-38-05	λ = 23° 35′ E
	Cartuja	11-37-50	2400		
	Leningrad	11-38-10	2450		Ekaterinburg gives
	Ekaterinburg	11-38-06	3280		ϕ = 38° 56′ N
	Hamburg	11-38-12	2010		λ = 24° 27′ E
	Helwan	11-38-23	900		
	Innsbruck	11-38-15	1390		
	Ithaca	11-37-59	8080		Strasbourg gives
	Pulkovo	11-38-10	2440		ϕ = 36° N
	Toledo	11-37-59	2350		λ = 23° E
	Almeria	11-37-57	2320		
	Malaga	11-38-01	2380		Zürich gives
	Alicante	11-38-02	2030		ϕ = 37° N
	Paris	11-38-10	2040		λ = 24° E
	San Fernando	11-38-06	2510		
	Strasbourg	11-37-54	1820		Makéevka gives
	Toronto	11-38-07	8100		ϕ = 37° 50′ N
	Uccle	11-38-04	2110		λ = 22° 29′ E
	Wien	11-37-48	1460		
	Zürich	11-38-03	1660		
	Agram	11-38-07	1120		
	Graz	11-38-17	1170		
	Firenze	11-37-43	1430		
	Makéevka	11-38-10	1690		
	Irkutsk	11-38-01	6240		
	Piatigorsk	11-38-13	1900		
	Halifax	11-38-12	6840		
Aug. 31	Ottawa	10-39-59	3860	ϕ = 38°·3 N	
2568	Barcelona	10-39-53	2760	λ = 30° W	
	Cartuja	10-39-59	2270	O = 10-39-58	
	Ekaterinburg	10-40-06	6550		
	Paris	10-40-08	2660		
	Pulkovo	10-39-54	4720		
	Strasbourg	10-40-01	3050		
	Uccle	10-39-49	2970		
	Zürich	10-39-52	3160		
	Toledo	10-39-42	2290		
	Almeria	10-40-10	2350		
	Malaga	10-39-59	2220		
	Alicante	10-40-18	2360		
	Leningrad	10-39-55	4700		
	Moncalieri	10-39-46	3200		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Sept. 2	Algiers	1–22–10	9350	ϕ = 33° S	Ekaterinburg gives
2570	Batavia	1–21–37	5990	λ = 59° E	ϕ = 34° 51′ S
	Belgrade	1–21–50	9520	O = 1–21–55	λ = 63° 8′ E
	Budapest	1–22–11	9480		
	Cartuja	1–21–40	10310		Makéevka gives
	Hamburg	1–21–42	10800		ϕ = 33° 34′ S
	Helwan	1–21–45	7750		λ = 58° 59′ E
	Innsbruck	1–22–07	9800		
	Almeria	1–22–06	9950		
	Malaga	1–21–49	10080		
	Alicante	1–21–47	10080		
	Makéevka	1–21–51	9330		
	Pulkovo	1–21–49	10600		
	San Fernando	1–21–53	10100		
	Baku	1–21–43	8520		
	Wien	1–22–00	9740		
	Zi-ka-wei	1–22–14	9350		
	Hohenheim	1–21–51	10260		
	Toledo	1–21–49	10310		
	Wellington	1–22–07	9200		
	Agram	1–22–01	9600		
	Graz	1–21–47	9980		
	Moncalieri	1–22–32	9940		
	Sydney	1–21–22	8680		
	Piatigorsk	1–22–17	8740		
Sept. 4	Ottawa	15–37–20	9080	ϕ = 44° N	Ekaterinburg gives
2572	Algiers	15–37–39	9400	λ = 144° E	ϕ = 44° 23′ N
	Batavia	15–36–59	6500	O = 15–37–09	λ = 144° 45′ E
	Budapest	15–37–14	8550		
	Cartuja	15–37–08	10260		Makéevka gives
	Ekaterinburg	15–36–59	5710		ϕ = 44° 38′ N
	Hamburg	15–37–11	8320		λ = 145°53′ E
	Innsbruck	15–37–32	8450		
	Nagasaki	15–36–50	1710		Pulkovo gives
	Makéevka	15–37–06	7550		ϕ = 44° 13′ N
	Paris	15–37–09	9050		λ = 145° 31′ E
	Pulkovo	15–37–05	7040		
	Moncalieri	15–37–06	9100		Irkutsk gives
	Strasbourg	15–37–10	8850		ϕ = 45°·0 N
	Baku	15–36–55	7530		λ = 143°·6 E
	Toronto	15–37–09	9200		
	Irkutsk	15–37–01	2960		
	Uccle	15–37–10	8780		
	Wien	15–37–08	8640		
	Zi-ka-wei	15–36–54	2320		
	Zürich	15–37–09	8950		
	Bergen	15–37–25	7750		
	Ravensburg	15–36–58	9020		
	Hohenheim	15–37–12	8750		
	Graz	15–37–09	8720		
	Agram	15–37–27	8640		
	Firenze	15–36–53	9440		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Sept. 7	Jinsen...........	12–22–55	5010	ϕ = 3° S	Ekaterinburg gives
2576	Ekaterinburg........	12–23–08	9940	λ = 152° E	ϕ = 6° 26′ S
	Makéevka..........	12–22–36	12020	O = 12–22–58	λ = 139° 36′ E
	Mizusawa..........	12–22–48	4950	Location approximate	
	Victoria..........	12–23–23	9820		
	Irkutsk...........	12–23–01	7490		
	Wellington.........	12–22–58	4740		
Sept. 10	Batavia...........	10–34–08	680	ϕ = 9° S	Ekaterinburg gives
2580	Jinsen...........	10–34–18	5430	λ = 113° E	ϕ = 8° 2′ S
	Ekaterinburg........	10–34–24	8650	O = 10–34–23	λ = 113° 31′ E
	Helwan...........	10–34–33	9340		
	Osaka...........	10–34–35	5360		Irkutsk gives
	Perth...........	10–34–17	2560		ϕ = 9°·1 S
	Pulkovo..........	10–34–04	10550		λ = 115°·2 E
	Mizusawa..........	10–34–25	6050		
	Baku...........	10–34–21	8380		
	Irkutsk...........	10–34–17	6900		
	Makéevka..........	10–34–28	9340		
	Sydney...........	10–34–16	4880		
	Agram...........	10–34–48	10850		
	Taihoku..........	10–34–34	3660		
	Wellington.........	10–34–16	7280		
Sept. 11	Ekaterinburg........	12–27–39	8540	ϕ = 10° S	
2581	Pulkovo..........	12–27–38	10180	λ = 109° E	
	Baku...........	12–27–33	8320	O = 12–27–34	
	Makéevka..........	12–27–37	9400		
	Irkutsk...........	12–27–25	6890		
Sept. 12	Algiers...........	15–43–55	10120	ϕ = 21° N	Ekaterinburg gives
2582	Jinsen...........	15–43–42	1770	λ = 130° E	ϕ = 25° 13′ N
	Ekaterinburg........	15–43–37	6170	O = 15–43–20	λ = 125° 29′ E
	Hamburg..........	15–43–07	10100	Location approximate	
	Manila...........	15–42–46	1490		Irkutsk gives
	Naples...........	15–42–49	10980		ϕ = 22°·6 N
	Pulkovo..........	15–43–48	7900		λ = 127°·8 E
	Victoria..........	15–43–55	9600		
	Agram...........	15–42–26	10950		
	Irkutsk...........	15–43–05	3850		
	Mizusawa..........	15–43–41	2550		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Sept. 16	Batavia	17-59-20	5600	ϕ = 10° S	Ekaterinburg gives
2585	Berkeley	17-59-29	9300	λ = 158° E	ϕ = 7° 19′ S
	Jinsen	17-59-14	6130	O = 17-59-15	λ = 155° 27′ E
	Toyooka	17-59-20	5440		
	Kobe	17-59-21	5360		Irkutsk gives
	Nagasaki	17-59-04	5600		ϕ = 8°·3 S
	Lick	17-59-17	9580		λ = 161°·1 E
	Melbourne	17-59·6	3520		
	Osaka	17-59-21	5310		
	Nagoya	17-59-06	5420		
	Wellington	17-59-07	3620		
	Mizusawa	17-59-04	5740		
	Irkutsk	17-59-17	8600		
	Denver		11320		
	Sydney	17-59-03	2750		
Sept. 19	Algiers	1-03-59	1690	ϕ = 35° N	Pulkovo gives
2593	Barcelona	1-03-15	2150	λ = 22° E	ϕ = 37° 12′ N
	Belgrade	1-03-41	1070	O = 1-03-45	λ = 20° 45′ E
	Budapest	1-04-04	1250		
	Cartuja	1-03-37	2440		Strasbourg gives
	Almeria	1-03-23	2330		ϕ = 36°·5 N
	Hamburg	1-04-23	1890		λ = 21° E
	Helwan	1-04-05	1010		
	Malaga	1-03-47	2360		Makéevka gives
	Paris	1-03-51	2160		ϕ = 35° 49′ N
	Pulkovo	1-03-51	2620		λ = 21° 47′ E
	San Fernando	1-03-50	2500		
	Strasbourg	1-03-38	1980		
	Uccle	1-03-54	2150		
	Agram	1-03-20	1580		
	Toledo	1-03-54	2300		
	Moncalieri	1-03-24	1760		
	Baku	1-03-37	2590		
	Makéevka	1-03-50	1900		
Sept. 23	Cartuja	15-11-00	2390	ϕ = 46° N	
2597	Ekaterinburg	15-11-17	5960	λ = 30° W	
	Paris	15-11-06	2450	O = 15-11-05	
	Pulkovo	15-10-57	4140		
	Uccle	15-11-06	2560		
Oct. 3	Ekaterinburg	8-26-30	6170	ϕ = 36°·5 N	Ekaterinburg gives
2608	Pulkovo	8-26-35	7600	λ = 142° E	ϕ = 38° 15′ N
	Mizusawa	8-26-24	315	O = 8-26-30	λ = 144° 10′ E

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 11	Cartuja	6-38-47	210	ϕ = 35°·3 N	Toledo gives
2614	Ekaterinburg	6-38-42	5180	λ = 4°·3 W	ϕ = 36° N
	Hamburg	6-38-26	2460	O = 6-38-45	λ = 3° 40′ W
	Ravensburg	6-38-28	2320		
	San Fernando	6-38-51	250		
	Uccle	6-38-40	1890		
	Graz	6-38-40	2100		
	Toledo	6-38-54	435		
	Almeria	6-38-52	160		
	Malaga	6-38-55	100		
	Alicante	6-38-55	240		
Oct. 11	Ekaterinburg	7-26-37	7770	ϕ = 7° N	
2615	Irkutsk	7-26-26	5300	λ = 124°·5 E	
	Baku	7-26-43	8150	O = 7-26-35	
Oct. 13	Ottawa	6-02-29	7020	ϕ = 51°·5 N	Baku gives
2616	Algiers	6-02-41	9730	λ = 178°·0 W	ϕ = 51°·7 N
	Belgrade	6-01-51	9940	O = 6-02-21	λ = 183°·1 E
	Berkeley	6-02·5	4340		
	Almeria	6-02-17	10200		Irkutsk gives
	Fordham	6-02-04	7800		ϕ = 56°·4 N
	Hamburg	6-02-14	8580		λ = 189°·9 E
	Baku	6-02-26	8820		
	Tacubaya	6-02-45	7450		Pulkovo gives
	Irkutsk	6-01-57	5200		ϕ = 52° 7′ N
	Lick	6-02-21	4650		λ = 183° 39′ E
	Paris	6-02-28	8880		
	Leningrad	6-02-25	7350		Zürich gives
	Kucino	6-02·8	7600		ϕ = 50° N
	Pulkovo	6-02-29	7340		λ = 180° E
	Toronto	6-02-26	6950		
	Victoria	6-02-19	3810		St. Louis gives
	Moncalieri	6-02-15	9340		ϕ = 50° N
	Zürich	6-02-33	8850		λ = 180° W
	St. Anne	6-02-33	7040		
	Graz	6-01-54	9650		
	Agram	6-02-18	9300		
	St. Louis	6-02-26	6700		
	Denver	6-02-11	5520		
	Spokane	6-02-21	4210		
	Firenze	6-02-27	9400		
	Nagasaki	6-02-09	4580		
	Sumoto	6-02-01	4050		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 13	Ottawa	14–17–58	6920	ϕ = 51°·0 N	St. Louis gives
2617	Belgrade	14–17–50	9170	λ = 178°·4 W	ϕ = 51° N
	Berkeley	14–17·3	4750	O = 14–17–47	λ = 178° W
	Budapest	14–17–36	9120		
	Cartuja	14–17–59	9980		Science Service gives
	Irkutsk	14–17–34	5020		ϕ = 50° N
	Ekaterinburg	14–17–42	6900		λ = 173° W
	Hamburg	14–17·8	8440		
	Makéevka	14–17–45	8520		Irkutsk gives
	Leningrad	14–17–49	7380		ϕ = 58°·7 N
	Tacubaya	14–17–49	7760		λ = 188°·9 E
	Naples		10140		
	Pulkovo	14–17–53	7340		Ekaterinburg gives
	Kucino	14–18·0	7720		ϕ = 50° 9′ N
	Toronto	14–17–48	6980		λ = 180° 23′ E
	Uccle	14–17–55	8700		
	Victoria	14–17–53	3720		Pulkovo gives
	Wien	14–17–35	9160		ϕ = 52° 3′ N
	Zürich	14–17–40	9230		λ = 183° 8′ E
	St. Anne	14–18–07	6950		
	Agram	14–18–02	9000		
	Denver	14–17–23	5620		
	Firenze	14–18–07	9300		
	Nagasaki	14–17–30	4630		
	Moncalieri	14–17–49	9320		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 13	Ottawa............	19-08-07	6780	ϕ = 50°·4 N	Ekaterinburg gives
2618	Algiers............	19-08-31	9730	λ = 174°·0 W	ϕ = 49° 3′ N
	Barcelona..........	19-07-51	9950	O = 19-08-08	λ = 180° 49′ E
	Belgrade...........	19-08-04	9480		
	Berkeley...........	19-08-08	4260		Pulkovo gives
	Budapest...........	19-08-28	8800		ϕ = 48° 50′ N
	Cartuja............	19-08-05	10200		λ = 180° 11′ E
	Irkutsk............	19-07-55	5310		
	Spokane............	19-08-29	4020		Zürich gives
	Hohenheim..........	19-07-56	9150		ϕ = 55° N
	Ekaterinburg.......	19-07-57	7020		λ = 177° W
	Fordham............	19-08-23	7180		
	Hamburg............	19-08-05	8550		St. Louis gives
	Leningrad..........	19-08-03	7630		ϕ = 51° N
	Ithaca.............	19-08-12	6950		λ = 178° W
	Makéevka...........	19-08-14	8580		
	Firenze............	19-08-47	9000		
	Nagasaki...........	19-07-57	4880		
	Lick...............	19-08-17	4220		
	Naples.............		10380		
	Osaka..............	19-08-10	4060		
	Toyooka............	19-08-09	4140		
	Pulkovo............	19-08-04	7620		
	Mizusawa...........	19-07-59	3550		
	San Fernando.......	19-07-25	10320		
	Strasbourg.........	19-08-15	8900		
	Jinsen.............	19-08-10	4560		
	Toronto............	19-08-09	6710		
	Tacubaya...........	19-07-54	7750		
	Uccle..............	19-08-12	8700		
	Victoria...........	19-08-14	3450		
	Kucino.............		7960		
	Wien...............	19-07-57	9250		
	Zi-ka-wei..........	19-08-07	5480		
	Zürich.............	19-08-07	9160		
	Halifax............	19-08-16	7490		
	Saskatoon..........	19-08-13	4400		
	Ste. Anne..........	19-08-12	6900		
	New Orleans........	19-07-57	7150		
	Graz...............	19-07-52	9480		
	Agram..............	19-08-01	9460		
	St. Louis..........	19-08-16	6370		
	Santa Clara........		3900		
	Denver.............		5300		
	Sumoto.............	19-08-03	4320		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 14 2619	Ottawa	2–11–09	6800	$\phi = 51°\cdot0$ N	Ekaterinburg gives
	Ekaterinburg	2–11–07	6990	$\lambda = 175°\cdot8$ W	$\phi = 49° 30'$ N
	Fordham	2–11–07	7390	O = 2–11–09	$\lambda = 181° 45'$ E
	Ithaca	2–11–08	7000		
	Pulkovo	2–11–15	7450		
	Toronto	2–11–06	6780		
	Victoria	2–11–05	3590		
	Ste. Anne	2–11–09	7020		
	Makéevka	2–11–18	8500		
Oct. 19 2622	Cartuja	20–48–01	9150	$\phi = 11°$ N	
	LaPaz	20–47–53	3980	$\lambda = 92°$ W	
	Sucre	20–47–49	4260	O = 20–47–54	
	Malaga	20–47–50	8840	Location approximate	
	Almeria	20–47–59	9160		
Oct. 22 2623	Cartuja	12–35–35	9450	$\phi = 37°\cdot6$ N	
	Ekaterinburg	12–35–29	9320	$\lambda = 124°\cdot4$ W	
	Fordham		4580	O = 12–35–20	
	Hamburg	12–35–24	8950		
	LaPaz	12–35–31	8080		
	Lick		120		
	Pulkovo	12–35–14	9010		
	Strasbourg	12–35–21	9300		
	Uccle	12–35–24	8940		
	Zürich	12–35–28	9200		
	Saskatoon	12–35–19	2140		
	Sucre	12–35–30	8540		
	St. Louis	12–35–10	2690		
	Denver		1150		
	Spokane	12–35–20	1230		
	Almeria	12–35–25	9750		
	Tacubaya	12–34–54	3200		
	Leningrad	12–35–14	9030		
Oct. 22 2624	Ekaterinburg	13–35–42	9320	$\phi = 37°$ N	
	Saskatoon	13–35–27	2140	$\lambda = 125°$ W	
	Sucre	13–35–20	8780	O = 13–35–30	
	Spokane	13–35–48	1110		
	Tacubaya	13–35–13	3150		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 22	Budapest...........	19-59-18	2220	ϕ = 40°·0 N	Ekaterinburg gives
2625	Ekaterinburg........	19-59-28	2190	λ = 43°·5 E	ϕ = 40° 4′ N
	Hamburg............	19-59-30	2810	O = 19-59-23	λ = 43° 24′ E
	Helwan.............	19-59-33	1670		
	Ravensburg.........	19-59-00	3040		Pulkovo gives
	Pulkovo............	19-59-28	2310		ϕ = 40°·5 N
	Uccle..............	19-59-24	3170		λ = 42°·9 E
	Wien...............	19-59-18	2400		
	Zürich.............	19-58-58	3120		Makéevka gives
	Hohenheim..........	19-59-10	2820		ϕ = 39° 56′ N
	Firenze............	19-59-30	2680		λ = 43° 13′ E
	Piatigorsk.........	19-59-26	440		
	Moncalieri.........	19-59-43	2770		
	Kucino.............	19-59-17	1850		
	Leningrad..........	19-59-29	2320		
	Irkutsk............	19-59-22	4670		
	Baku...............	19-59-36	530		
	Makéevka...........	19-59-25	990		
Oct. 23	Belgrade...........	1-58-23	660	ϕ = 39°·0 N	Belgrade gives
2626	Cartuja............	1-58-50	2070	λ = 19°·8 E	ϕ = 42° 20′ N
	Ekaterinburg........	1-58-50	3210	O = 1-58-37	λ = 18° 40′ E
	Hamburg............	1-59·3	1750		
	Naples.............	1-58-08	450		
	Pulkovo............	1-58-35	2310		
	Strasbourg.........	1-58-43	1440		
	Wien...............	1-58-11	1230		
	Almeria............	1-58-52	2000		
	Moncalieri.........	1-58-26	1260		
	Leningrad..........	1-58-35	2320		
Oct. 26	Ekaterinburg........	3-44-52	9350	ϕ = 1° S	Ekaterinburg gives
2630	Baku...............	3-44-42	10060	λ = 140° E	ϕ = 1° 15′ S
	Melbourne..........	3-44·5	3810	O = 3-44-43	λ = 137° 52′ E
	Osaka..............	3-44-48	3900		
	Wellington.........	3-44-35	5400		Pulkovo gives
	Jinsen.............	3-44-42	4440		ϕ = 1° 11′ N
	Nagoya.............	3-44-30	4000		λ = 139° 17′ E
	Pulkovo............	3-44-47	10940		
	Mizusawa...........	3-44-49	4380		Leningrad gives
	Leningrad..........	3-44-47	10960		ϕ = 2° 3′ N
	Irkutsk............	3-44-46	6870		λ = 141° 23′ E
	Zi-ka-wei..........	3-44-37	4060		
	Piatigorsk.........	3-44-42	10400		Irkutsk gives
	Apia...............	3-45-31	5500		ϕ = 2°·5 S
	Sydney.............	3-44-24	3600		λ = 138°·5 E
	Nagasaki...........	3-44-34	3960		
	Kobe...............	3-44-34	4050		
	Toyooka............	3-44-43	4050		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 27 2633	Ekaterinburg	4–58–46	9450	ϕ = 19° N	
	Pulkovo	4–58–55	10690	λ = 173° E	
	Irkutsk	4–58–36	6990	O = 4–58–45	
				Location approximate	
Oct. 29 2635	Ekaterinburg	0–08–43	6750	ϕ = 16° N	
	Pulkovo	0–08–51	8450	λ = 122° E	
	Leningrad	0–08–51	8450	O = 0–09 ca.	
	Makéevka	0–09–39	7670	Location approximate	
Oct. 30 2638	Batavia	10–11–19	2820	ϕ = 17° N	Pulkovo gives
	Pulkovo	10–11–33	8440	λ = 121°·5 E	ϕ = 15° 53′ N
	Wien	10–11–44	9400	O = 10–11–30	λ = 119° 32′ E
	Zi-ka-wei	10–11–20	1780		
	Kucino	10–11–35	7990		
	Leningrad	10–11–36	8420		
	Irkutsk	10–11–24	4150		
Oct. 30 2639	Berkeley	19–41–47	1420	ϕ = 49° N	
	Ekaterinburg	19–41–39	8480	λ = 128°·5 W	
	Fordham	19–41–46	4210	O = 19–41–53	
	Hamburg	19–42·3	7900		
	Lick	19–41–50	1490		
	Pulkovo	19–42–02	7800		
	Toronto	19–42–00	3590		
	St. Louis	19–41–44	3270		
	Denver	19–42–16	2320		
	Sucre	19–42–05	9740		
	Kucino	19–41·8	8440		
	Spokane	19–41–29	1080		
	Irkutsk	19–42–04	7700		
	Makéevka	19–41–38	9400		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 1	Ottawa............	1-39-09	3840	ϕ = 48°·8 N	Leningrad gives
2640	Berkeley..........	1-39-10	1400	λ = 131°·1 W	ϕ = 47° 21′ N
	Budapest..........	1-38-57	9250	O = 1-39-17	λ = 121° 8′ W
	Irkutsk...........	1-39-43	7550		
	Tacubaya..........	1-39-00	4120		Pulkovo gives
	Ekaterinburg.......	1-39-24	8250		ϕ = 48° 5′ N
	Hamburg...........	1-39-18	8120		λ = 124° 33′ W
	Ithaca............	1-39-07	4040		
	Leningrad..........	1-39-26	7780		
	Lick..............	1-39-21	1410		
	Kucino............	1-39-22	8380		
	Pulkovo...........	1-39-24	7800		
	Wien..............	1-39-18	8850		
	Saskatoon..........	1-39-01	1780		
	St. Louis..........	1-39-18	3120		
	Santa Clara........	1-39-12	1440		
	Spokane...........	1-39-14	875		
	Firenze...........	1-39-28	9080		
	Denver............	1-39-53	2280		
	Baku..............	1-39-26	10000		
Nov. 1	Ekaterinburg.......	15-05-24	7250	ϕ = 52° N	
2641	Baku..............	15-05-27	9250	λ = 162°·5 W	
	Irkutsk...........	15-05-17	5900	O = 15-05-23	
Nov. 2	Ekaterinburg.......	19-46-10	5850	ϕ = 46° N	Pulkovo gives
2643	Leningrad..........	19-45-55	7350	λ = 156° E	ϕ = 36°·7 N
	Kucino............	19-46-07	7150	O = 19-45-55	λ = 136°·0 E
	Osaka.............	19-46-22	1910		
	Pulkovo...........	19-45-54	7340		
	Zi-ka-wei..........	19-45-25	3470		
	Baku..............	19-45-56	8050		
	Irkutsk...........	19-45-46	3620		
	Sumoto............	19-45-51	2210		
	Jinsen............	19-45-46	2470		
Nov. 2	Budapest..........	21-09-36	8740	ϕ = 46°·5 N	Leningrad gives
2644	Ekaterinburg.......	21-09-25	6020	λ = 156° E	ϕ = 46° 43′ N
	Leningrad..........	21-09-29	7180	O = 21-09-22	λ = 156° 1′ E
	Kucino............	21-09-29	7220		
	Osaka.............	21-09-34	2010		Pulkovo gives
	Pulkovo...........	21-09-29	7200		ϕ = 46°·2 N
	Zi-ka-wei..........	21-09-02	3380		λ = 154°·8 E
	Firenze...........	21-09-25	9520		
	Jinsen............	21-09-12	2460		
	Irkutsk...........	21-08-42	3810		
	Makéevka..........	21-09-35	7800		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 5	Ottawa............	7–55–30	3520	ϕ = 14°·2 N	Ekaterinburg gives
2646	Barcelona..........	7–55–38	8770	λ = 85°·5 W	ϕ = 14° 50′ N
	Berkeley..........	7–55–43	4080	O = 7–55–39	λ = 86° 50′ W
	Cartuja..........	7–55–39	8400		
	Kucino..........	7–55–39	10400		Pulkovo gives
	Fordham..........	7–55–27	3200		ϕ = 16° 47′ N
	Ithaca..........	7–55–33	3180		λ = 90° 55′ W
	LaPaz..........	7–55–38	3500		
	Hohenheim..........	7–55–28	9160		
	Jena..........	7–55·8	9050		
	Paris..........	7–55–43	8620		
	Alicante..........	7–55–22	8900		
	Malaga..........	7–55–38	8360		
	San Fernando.......	7–55–43	8180		
	Tacubaya..........	7–55–21	1530		
	Graz..........	7–55–58	9160		
	Toronto..........	7–55–31	3240		
	Uccle..........	7–55–38	8750		
	Wien..........	7–56–01	9150		
	Almeria..........	7–55–44	8420		
	Zürich..........	7–55–47	8940		
	Saskatoon..........	7–55–47	4400		
	Halifax..........	7–55–34	3900		
	Agram..........	7–55–04	10400		
	St. Louis..........	7–55–35	2700		
	La Plata..........	7–55·6	5880		
	Spokane..........	7–55–26	4550		
	Sucre..........	7–55–35	3900		
	Firenze..........	7–56–14	8840		
	Denver..........	7–56–31	3200		
	New Orleans........	7–55–18	1930		
Nov. 7	Ekaterinburg........	16–01–47	9480	ϕ = 2° S	
2648	Baku..........	16–01–33	10260	λ = 140° E	
	Irkutsk..........	16–01–40	7010	O = 16–01–40	
				Location approximate	
Nov. 11	Ekaterinburg........	3–01–20	6320	ϕ = 38° N	
2652	Zi-ka-wei..........	3–01–06	2220	λ = 145° E	
	Toyooka..........	3–01–03	930	O = 3–01–12	
	Irkutsk..........	3–01–18	3360	Location approximate	
Nov. 13	Ekaterinburg........	3–41–20	6850	ϕ = 47° N	
2654	Leningrad..........	3–41–06	7620	λ = 175°·5 E	
	Kucino..........	3–41–22	7680	O = 3–41–15	
	Pulkovo..........	3–41–06	7660		
	Baku..........	3–41–13	9050		
	Irkutsk..........	3–41–22	4900		

LOCATION OF EPICENTRES, 1926

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 23	Ekaterinburg........	0-20-15	5970	ϕ = 47° N	
2658	Leningrad...........	0-20-15	7200	λ = 155° E	
	Pulkovo............	0-20-16	7150	O = 0-20-17	
	Baku...............	0-20-13	7960		
	Irkutsk............	0-20-02	3580		
	Makéevka...........	0-20-20	7850		
	Mizusawa...........	0-20-39	1220		
Nov. 27	Pulkovo............	5-19-30	9100	ϕ = 11° N	
2660	Zi-ka-wei..........	5-19-08	2380	λ = 124° E	
	Baku...............	5-19-23	8050	O = 5-19-20	
	Sumoto.............	5-18-43	3120		
	Piatigorsk.........	5-19-50	8520		
	Irkutsk............	5-19-17	4850		
	Makéevka...........	5-19-34	8750		
Dec. 17	Algiers............	6-31-07	1530	ϕ = 40°·8 N	Pulkovo gives
2672	Belgrade...........	6-31-07	410	λ = 19°·8 E	ϕ = 41° 6′ N
	Cartuja............	6-31-25	1950	O = 6-31-16	λ = 19° 19′ E
	Alicante...........	6-31-23	1800		
	Malaga.............	6-31-32	1990		
	Toledo.............	6-31-34	1880		
	Agram..............	6-31-04	620		
	Leningrad..........	6-31-01	2200		
	Ekaterinburg.......	6-31-02	3270		
	Hamburg............	6-31-11	1560		
	Pulkovo............	6-31-02	2210		
	Karlsruhe..........	6-31-25	1170		
	Zürich.............	6-31-37	1000		
	Graz...............	6-31-15	730		
Dec. 17	Algiers............	11-39-46	1600	ϕ = 41°·3 N	Leningrad gives
2673	Belgrade...........	11-40-01	380	λ = 18°·5 E	ϕ = 42° 4′ N
	Cartuja............	11-40-01	2030	O = 11-40-02	λ = 17° 38′ E
	Leningrad..........	11-39-53	2170		
	Irkutsk............	11-39-53	6240		Pulkovo gives
	Ekaterinburg.......	11-39-51	3250		ϕ = 41° 30′ N
	Naples.............	11-40-33	225		λ = 18° 11′ E
	Pulkovo............	11-39-52	2200		
	Moncalieri.........	11-40-23	1040		
	Agram..............	11-40-03	590		
	Graz...............	11-40-24	530		
	Toledo.............	11-40-07	1900		
	Almeria............	11-39-54	2040		
	Malaga.............	11-39-55	2150		
	Alicante...........	11-39-45	1780		
	Jena...............	11-40-07	1200		
Dec. 19	Ekaterinburg.......	9-17-49	5550	ϕ = 52° N	
2674	Pulkovo	9-17-48	3700	λ = 33° W	
	Uccle..............	9-17-54	2470	O = 9-17-50	
	Baku...............	9-17-49	6190		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Jan. 7 2686	Ekaterinburg........ Pulkovo............ Leningrad........... Irkutsk............	10–42–53 10–42–56 10–42–58 10–43–16	3250 3380 3410 2990	ϕ = 80° N λ = 116° E O = 10–43–00	
Jan. 17 2690	Ekaterinburg........ Pulkovo............ Zi-ka-wei........... Jinsen............. Graz............... Kobe............... Tiflis.............. Tachkent........... Leningrad........... Makéevka.......... Irkutsk............	21–58–12 21–58–17 21–57–33 21–58–28 21–58–28 21–58–32 21–58–16 21–58–11 21–58–16 21–58–12 21–58–08	6020 7450 2390 1270 9010 630 7780 5990 7430 7900 3170	ϕ = 38°·0 N λ = 141°·9 E O = 21–58–14	Ekaterinburg gives ϕ = 38° 13′ N λ = 141° 41′ E Pulkovo gives ϕ = 38° 41′ N λ = 142° 38′ E Irkutsk gives ϕ = 44° N λ = 145°·9 E
Jan. 24 2697	Apia............... Melbourne.......... Osaka.............. Wellington.......... Suva............... Nagasaki........... Jinsen..............	1–05–16 1–05·5 1–05–31 1–05–35 1–06·0 1–05–40 1–05–46	2420 3150 6880 2610 1000 6980 7500	ϕ = 17° S λ = 167° E O = 1–05·6 Location approximate	Ekaterinburg gives ϕ = 16° 38′ S λ = 161° 54′ E Irkutsk gives ϕ = 4°·2 S λ = 163°·7 E
Jan. 24 2698	Sydney............. Wellington.......... Irkutsk............	6–42–04 6–42–15 6–42–13	2510 2620 10050	ϕ = 19° S λ = 170° E O = 6–42–10 Location approximate	
Jan. 25 2701	Sydney............. Wellington.......... Suva............... Apia............... Irkutsk............	23–09–38 23–10–43 23–10·7 23–10–12 23–10–39	2820 2550 1120 2470 9880	ϕ = 16° S λ = 167° E O = 23–10·4 Location and O approximate.	
Jan. 26 2702	Sydney............. Wellington.......... Suva............... Apia............... Irkutsk............	15–35–42 15–36–25 15–36·1 15–36–37 15–37–02	2660 2590 1120 2340 9480	ϕ = 14° S λ = 166° E O = 15–36·4 Location and O approximate.	

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Feb. 1	Ekaterinburg........	17-56-51	10300	ϕ = 6°·5 S	Ekaterinburg gives
2708	Melbourne...........	17-56·6	3520	λ = 151°·3 E	ϕ = 4°·5 S
	Perth...............	17-56-43	4680	O = 17-56-39	λ = 153°·6 E
	Victoria............	17-56-46	9600		
	Sydney..............	17-55-57	3070		Tachkent gives
	Taihoku.............	17-56-38	4830		ϕ = 1°·2 N
	Tachkent............	17-56-47	9800		λ = 158°·1 E
	Baku................	17-57-16	10560		
	Spokane.............	17-56-13	10550		Irkutsk gives
	Irkutsk.............	17-56-45	7920		ϕ = 4°·2 S
					λ = 156°·2 E
Feb. 3	Ekaterinburg........	3-53-04	5150	ϕ = 33° N	Irkutsk gives
2709	Pulkovo.............	3-53-10	6900	λ = 122° E	ϕ = 32°·1 N
	Nagasaki............	3-53-22	860	O = 3-53-04	λ = 119°·6 E
	Jinsen..............	3-52-41	910		
	Makéevka............	3-53-09	6890		
	Baku................	3-53-00	6350		
	Leningrad...........	3-53-10	6930		
	Irkutsk.............	3-53-00	2560		
	Changtun............	3-53-04	340		
Feb. 14	Algiers.............	3-43-01	1630	ϕ = 42°·8 N	Kucino gives
2716	Barcelona...........	3-43-12	1460	λ = 17°·7 E	ϕ = 41° 42′ N
	Belgrade............	3-43-14	340	O = 3-43-21	λ = 20° 23′ E
	Cartuja.............	3-44-15	2030		
	Baku................	3-43-13	2650		Pulkovo gives
	Tiflis..............	3-43-15	2220		ϕ = 43°·2 N
	Hamburg.............	3-43-26	1300		λ = 18°·2 E
	Helwan..............	3-43-22	1860		
	Lemberg.............	3-43-14	1000		Strasbourg gives
	Kucino..............	3-43-24	2000		ϕ = 42°·5 N
	Makéevka............	3-43-28	1640		λ = 18° E
	Irkutsk.............	3-43-14	6180		
	Paris...............	3-43-46	1240		Zürich gives
	Pulkovo.............	3-43-20	2020		ϕ = 43° N
	Karlsruhe...........	3-43-32	980		λ = 18° E
	Stonyhurst..........	3-43-07	2035		
	Strasbourg..........	3-43-13	1070		Leningrad gives
	Leningrad...........	3-43-26	2010		ϕ = 43°·8 N
	Uccle...............	3-43-04	1500		λ = 16°·8 E
	Zürich..............	3-43-18	930		
	Richmond............	3-43-23	1720		Wien gives
	Ravensburg..........	2-43-12	940		ϕ = 43°·7 N
	Hohenheim...........	3-43-10	1040		λ = 17°·5 E
	Firenze.............	3-43-34	490		
	Helsingfors.........	3-43-14	1990		
	Toledo..............	3-42-41	2200		
	Almeria.............	3-43-32	1850		
	Malaga..............	3-43-28	1990		
	Alicante............	3-43-46	1610		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Feb. 16	Ottawa............	1-35-17	8800	ϕ = 45°·8 N	Kucino gives
2719	Algiers............	1-35-51	9560	λ = 154°·0 E	ϕ = 47° 35′ N
	Barcelona..........	1-35-32	9730	O = 1-35-18	λ = 156° 10′ E
	Belgrade...........	1-35-19	8970		
	Berkeley...........	1-35-23	6710		Ekaterinburg gives
	Cartuja............	1-35-23	10180		ϕ = 46° 2′ N
	Kucino.............	1-34-20	7220		λ = 151° 26′ E
	Makéevka..........	1-35-12	8070		
	Ekaterinburg........	1-35-20	5930		Leningrad gives
	Fordham...........	1-35-26	9250		ϕ = 46°·0 N
	Hamburg...........	1-35-21	8480		λ = 159°·2 E
	Tiflis..............	1-35-15	8160		
	Helwan............	1-35-43	9340		Irkutsk gives
	Leningrad..........	1-35-12	7340		ϕ = 48°·5 N
	Irkutsk............	1-35-12	3450		λ = 153°·6 E
	Paris..............	1-35-30	9010		
	Toledo.............	1-35-50	9560		Pulkovo gives
	Almeria............	1-35-13	10050		ϕ = 46°·4 N
	Malaga............	1-35-34	10220		λ = 158°·9 E
	Alicante...........	1-35-31	9820		
	Frankfurt..........	1-35-24	8800		Tachkent gives
	Nagoya............	1-34-59	2080		ϕ = 38°·9 N
	Tachkent..........	1-35-14	6580		λ = 149°·6 E
	Kobe..............	1-35-16	2070		
	Pulkovo...........	1-35-12	7320		Strasbourg gives
	Stonyhurst.........	1-35-09	8880		ϕ = 48° N
	Strasbourg.........	1-35-25	8940		λ = 152° E
	Toronto...........	1-35-27	8740		
	Firenze...........	1-35-37	9200		Zürich gives
	Jena..............	1-35-30	8550		ϕ = 45° N
	Uccle.............	1-35-19	8910		λ = 150° E
	Victoria...........	1-35-20	5900		
	Wien..............	1-34-57	9250		
	Zürich............	1-35-23	9060		
	Saskatoon.........	1-35-19	6710		
	Nagasaki..........	1-35-03	2660		
	Jinsen............	1-35-12	2470		
	Richmond..........	1-35-27	8830		
	Karlsruhe.........	1-35-22	9000		
	Agram.............	1-34-30	8870		
	Ravensburg........	1-35-13	9120		
	Hohenhiem.........	1-35-22	8950		
	Graz..............	1-35-21	8930		
	Baku..............	1-35-11	8080		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Feb. 16	Paris	8-37-13	8620	ϕ = 48° N	
2720	Pulkovo	8-36-47	7100	λ = 157° E	
	Uccle	8-36-41	8880	O = 8-36-34	
	Kucino	8-35-40	7340		
	Tachkent	8-36-43	6470		
	Baku	8-36-34	8050		
	Irkutsk	8-36-18	3650		
Feb. 16	Ekaterinburg	11-52-29	5970	ϕ = 48° N	
2721	Paris	11-52-43	9000	λ = 158° E	
	Pulkovo	11-52-24	7340	O = 11-52-29	
	Uccle	11-52-51	8540	Location approximate	
	Graz	11-52-10	9300		
	Firenze	11-52-37	9000		
	Baku	11-52-26	8050		
	Tiflis	11-52-33	8080		
	Irkutsk	11-52-15	3590		
	Leningrad	11-52-26	7300		
Feb. 16	Ekaterinburg	13-57-54	5950	ϕ = 50° N	
2722	Tachkent	13-58-02	6400	λ = 159°·5 E	
	Baku	13-57-49	8080	O = 13-57-48	
	Irkutsk	13-57-29	3660	Location approximate	
Feb. 18	Ekaterinburg	22-56-27	7990	ϕ = 5° N	Ekaterinburg gives
2723	Pulkovo	22-56-26	9630	λ = 125° E	ϕ = 3° 45′ N
	Kucino	22-56-23	9380	O = 22-56-28	λ = 122° 56′ E
	Makéevka	22-56-30	9220	Location approximate	
	Tachkent	22-57-31	7060		Irkutsk gives
	Baku	22-56-19	8550		ϕ = 7°·7 N
	Leningrad	22-56-28	9650		λ = 132°·0 E
	Tiflis	22-56-29	8800		
	Irkutsk	22-56-16	5560		
Feb. 21	Ekaterinburg	12-25-13	8230	ϕ = 1°·5 N	Ekaterinburg gives
2725	Pulkovo	12-25-11	9980	λ = 123° E	ϕ = 3° 23′ N
	Kucino	12-25-11	9550	O = 12-25-11	λ = 126° 11′ E
	Makéevka	12-25-10	9500	Location approximate	
	Tachkent	12-25-03	7100		Tachkent gives
	Baku	12-25-13	8540		ϕ = 1°·2 N
	Leningrad	12-25-11	9980		λ = 125°·0 E
	Tiflis	12-26-12	8900		
	Irkutsk	12-24-57	6150		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Feb. 22	Ekaterinburg	19–54–14	7140	ϕ = 33° N	
2726	Pulkovo	19–53–39	9030	λ = 150° E	
	Tachkent	19–54–01	6970	O = 19–54–09	
	Tiflis	19–54–45	8400	Location approximate	
	Irkutsk	19–54–06	4210		
Feb. 28	Ottawa	14–08–01	8150	ϕ = 28° S	Ekaterinburg gives
2732	Fordham	14–08–41	7250	λ = 77° W	ϕ = 25° 18′ S
	La Paz	14–07–17	1610	O = 14–07–59	λ = 73° 57′ W
	Toronto	14–08–22	7680	Location approximate	
	St. Louis	14–07–59	7660		La Plata gives
	La Plata	14–08·0	1360		ϕ = 29° S
	Sucre	14–07–30	1430		λ = 70°·5 W
Mar. 3	Baku	1–05–03	9130	ϕ = 7° S	Ekaterinburg gives
2734	Tiflis	1–05–03	9480	λ = 123° E	ϕ = 4° 55′ S
	Ekaterinburg	1–05–12	8820	O = 1–05–07	λ = 122° 30′ E
	Tachkent	1–05–01	7620		
	Irkutsk	1–05–01	6800		Irkutsk gives
	Kucino	1–04–48	10530		ϕ = 6°·4 S
	Leningrad	1–05–09	10570		λ = 124°·6 E
	Perth	1–05–16	2730		
	Pulkovo	1–05–08	10550		
	Sydney	1–05–21	3950		
	Jinsen	1–04–56	4890		
	Taihoku	1–05–25	3420		
	Toyooka	1–05–05	4750		
Mar. 3	Ekaterinburg	16–50–04	6080	ϕ = 44°·2 N	Ekaterinburg gives
2735	Irkutsk	16–50–03	3470	λ = 151°·0 E	ϕ = 43° 51′ N
	Tachkent	16–50–10	6420	O = 16–50–06	λ = 150° 54′ E
	Paris	16–50–10	9250		
	Pulkovo	16–50–09	7280		Irkutsk gives
	Strasbourg	16–50–16	9010		ϕ = 42°·6 N
	Uccle	16–50–06	9010		λ = 149°·1 E
	Nagasaki	16–49–53	2470		
	Richmond	16–50–06	9100		Tachkent gives
	Kobe	16–49–57	2010		ϕ = 43°·4 N
	Sumoto	16–50–08	1970		λ = 151°·0 E
	Kucino	16–50–15	7250		
	Baku	16–50–08	7950		Pulkovo gives
	Tiflis	16–50–05	8160		ϕ = 43°·1 N
	Leningrad	16–50–08	7300		λ = 148°·8 E
					Leningrad gives
					ϕ = 42°·4 N
					λ = 147°·9 E

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Mar. 7	Ottawa	9-27-54	10230	ϕ = 35°·5 N	Science Service gives
2738	Leningrad	9-27-42	7390	λ = 135°·4 E	ϕ = 35°·4 N
	Kucino	9-27-42	7220	O = 9-27-41	λ = 135°·2 E
	Belgrade	9-27-52	8850		
	Berkeley	9-27-43	8650		Leningrad gives
	Cartuja	9-27-31	10950		ϕ = 36°·2 N
	Makéevka	9-27-34	7700		λ = 136°·4 E
	Baku	9-27-40	7240		
	Ekaterinburg	9-27-35	5820		Kucino gives
	Fordham	9-27-28	10980		ϕ = 36° 29′ N
	Hamburg	9-27-25	8950		λ = 136° 41′ E
	Nagoya	9-27-47	110		
	Helwan	9-27-50	9080		Ekaterinburg gives
	Tachkent	9-27-35	5600		ϕ = 36° 40′ N
	Lick	9-27-42	8820		λ = 135° 58′ E
	Manila	9-27-13	2880		
	Paris	9-27-56	9250		Tachkent gives
	Toledo	9-27-45	10380		ϕ = 32°·1 N
	Almeria	9-27-33	10850		λ = 132°·5 E
	Perth	9-28-00	7600		
	Sydney	9-27-55	7780		Pulkovo gives
	Frankfurt	9-27-46	9060		ϕ = 35° 55′ N
	Pulkovo	9-27-40	7380		λ = 135° 23′ E
	Stonyhurst	9-27-36	9300		
	Strasbourg	9-27-48	9150		Irkutsk gives
	Irkutsk	9-27-29	2990		ϕ = 36°·0 N
	Jena	9-27-54	8720		λ = 134°·8 E
	Tiflis	9-27-40	7530		
	Uccle	9-27-45	9190		Strasbourg gives
	Victoria	9-27-44	7920		ϕ = 35°·5 N
	Wien	9-27-42	8900		λ = 137° E
	Zürich	9-27-48	9230		
	Changtun	9-27-39	1460		
	Karlsruhe	9-27-40	9230		
	Nagasaki	9-27-47	580		
	Richmond	9-27-46	9310		
	Agram	9-27-29	9370		
	Jinsen	9-27-29	860		
	Hohenheim	9-27-45	9160		
	Graz	9-27-43	9050		
	Denver	9-27-48	9550		
	Firenze	9-28-05	9250		
	Helsingfors	9-27-19	7800		
Mar. 14	Ekaterinburg	17-37-37	4690	ϕ = 25°·2 N	Ekaterinburg gives
2745	Pulkovo	17-37-35	6640	λ = 103°·5 E	ϕ = 26° 50′ N
	Jinsen	17-37-39	2560	O = 17-37-34	λ = 102° 34′ E
	Baku	17-37-30	5160		
	Irkutsk	17-37-29	2930		Irkutsk gives
					ϕ = 25°·9 N
					λ = 104°·3 E

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Mar. 15	Ekaterinburg........	21–48·7	3240	ϕ = 38°·3 N	Ekaterinburg gives
2747	Pulkovo...........	21–48–26	5150	λ = 97°·5 E	ϕ = 38° 25′ N
	Jinsen...........	21–48–33	2520	O = 21–48–30	λ = 95° 28′ E
	Kucino...........	21–48–34	4600		
	Makéevka..........	21–48–26	4820		Irkutsk gives
	Baku............	21–48–28	4020		ϕ = 38°·6 N
	Tiflis............		4450		λ = 97°·7 E
	Irkutsk...........	21–48–39	1600		
	Tachkent..........	21–48–20	2530		Tachkent gives
	Leningrad..........	21–48–28	5150		ϕ = 37°·5 N
					λ = 98°·5 E
Mar. 16	Ekaterinburg........	6–52–33	5860	ϕ = 41°·5 N	Ekaterinburg gives
2748	Pulkovo...........	6–52–40	7420	λ = 148° E	ϕ = 43° 51′ N
	Makéevka..........	6–52–23	8180	O = 6–52–26	λ = 146° 39′ E
	Baku............	6–52–31	7750	Location approximate	
	Tiflis............	6–51·7	7960		
	Tachkent..........	6–52–47	5840		
Mar. 20	Ekaterinburg........	16–13–23	6900	ϕ = 50° N	
2751	Baku............	16–13–06	9230	λ = 173° W	
	Irkutsk...........	16–12–52	5400	O = 16–13–07	
Mar. 20	Ekaterinburg........	21–13–52	8300	ϕ = 2°·8 N	Irkutsk gives
2752	Baku............	21–13–49	8740	λ = 127°·8 E	ϕ = 4°·2 N
	Irkutsk...........	21–13–40	5890	O = 21–13–46	λ = 131°·2 E
	Tachkent..........	21–13–45	7180		
Mar. 21	Baku............	9–58–34	9230	ϕ = 47° N	
2754	Irkutsk...........	9–58–29	5300	λ = 180° W	
	Tachkent..........	9–58–36	7950	O = 9–58–33	
				Location approximate	

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Mar. 21	Algiers	15-05-49	9330	ϕ = 32° S	
2755	Barcelona	15-06-10	9350	λ = 60° E	
	Ekaterinburg	15-05-42	9870	O = 15-05-44	
	Helwan	15-05-34	7600		
	Strasbourg	15-06-10	9480		
	Wien	15-05-38	9820		
	Zi-ka-wei	15-05-51	9520		
	Graz	15-06-01	9350		
	Alicante	15-05-58	9700		
	Malaga	15-05-33	10100		
	Almeria	15-05-44	9890		
	Toledo	15-05-36	10250		
	Makéevka	15-05-43	9150		
	Baku	15-05-33	8360		
	Irkutsk	15-05-03	10260		
	Tachkent	15-05-38	8400		
Mar. 22	Ekaterinburg	0-59-22	6970	ϕ = 48° N	
2756	Zi-ka-wei	0-59-10	5550	λ = 175° W	
	Baku	0-59-10	9200	O = 0-59-12	
	Irkutsk	0-58-50	5500		
	Tachkent	0-59-28	7920		
Mar. 25	Ekaterinburg	12-55-03	7100	ϕ = 55° ·2 N	Ekaterinburg gives
2760	Pulkovo	12-55-00	7220	λ = 156°·7 W	ϕ = 53° 39′ N
	Kucino	12-55-03	7590	O = 12-55-03	λ = 163° 16′ W
	Makéevka	12-55-03	8440		
	Baku	12-54-53	9310		Pulkovo gives
	Tiflis	12-55·7	9150		ϕ = 55°·3 N
	Leningrad	12-55-01	7200		λ = 149°·7 W
	Tachkent	12-55-03	8400		
Mar. 31	Ekaterinburg	21-08-26	5950	ϕ = 38°·0 N	Tachkent gives
2768	Jinsen	21-08-35	830	λ = 137° ·5 E	ϕ = 24°·6 N
	Baku	21-08-32	7320	O = 21-08-36	λ = 128°·0 E
	Tiflis	21-08-56	7350	Location approximate	
	Irkutsk	21-08-35	2970		
	Tachkent	21-08-31	5660		
April 1	Hamburg	19-13-27	8380	ϕ = 41° N	
2770	Helwan	19-13-12	8850	λ = 135° E	
	Paris	19-13-25	8680	O = 19-13-23	
	Strasbourg	19-13-11	8830	Location approximate	
	Uccle	19-13-18	8650		
	Zürich	19-13-27	8720		
	Richmond	19-13-28	8500		
	Graz	19-13-33	8550		
	Karlsruhe	19-13-27	8650		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
April 14 2779	Ottawa	6–23–46	8320	$\phi = 31°\cdot 0$ S	LaPaz gives
	Fordham	6–23–39	8000	$\lambda = 70°\cdot 3$ W	$\phi = 32°\cdot 2$ S
	Ithaca	6–23–40	8150	O = 6–23–35	$\lambda = 69°\cdot 5$ W
	LaPaz	6–23–29	1800		
	Sucre	6–23–04	1620		
	La Plata	6–23–35	1060		
	Lick	6–23–31	9320		
	Apia	6–23–48	9850		
	Wellington	6–23–41	9220		
	Toronto	6–23–34	8350		
	Ste. Anne	6–23–41	8620		
	Zürich	6–23–33	11320		
	St. Louis	6–23–22	7980		
	Chicago	6–23–34	8350		
	New Orleans	6–23–28	7220		
	Almeria	6–23–38	10050		
	Malaga	6–23–41	9900		
	Alicante	6–23–49	9880		
April 16 2781	Ottawa	(8–15–30)	6650	$\phi = 51°\cdot 6$ N	
	Fordham	8–15–14	7380	$\lambda = 177°\cdot 6$ W	
	Paris	8–14–35	9480	O = 8–15–00	
	Pulkovo	8–15–10	7280		
	Toronto	8–14–28	7180		
	Uccle	8–15–01	8700		
	Victoria	8–14–58	3690		
	Zi-ka-wei	8–14–53	5300		
	Zürich	8–15–06	8980		
	Ste. Anne	8–15–34	6820		
	Agram	8–15–09	9080		
	Richmond	8–14–39	8980		
	Malaga	8–14–49	10130		
	Baku	8–15–02	8870		
	Irkutsk	8–14–56	4960		
	Tachkent	8–14–52	7980		
	Toyooka	8–15–21	3740		
April 19 2783	Belgrade	17–30–13	9160	$\phi = 18°$ N	Irkutsk gives
	Tachkent	17–30–06	5420	$\lambda = 120°$ E	$\phi = 18°\cdot 9$ N
	Ekaterinburg	17–30–13	6550	O = 17–30–15	$\lambda = 122°\cdot 4$ E
	Hamburg	17–30–32	9210	Location approximate	
	Helwan	17–30–12	8820		
	Irkutsk	17–30–06	4020		
	Tiflis	17–30–11	7480		
	Paris	17–30–09	10250		
	Pulkovo	17–30–14	8230		
	Strasbourg	17–30–17	9820		
	Uccle	17–20–12	9950		
	Leningrad	17–30–15	8250		
	Agram	17–30–42	8950		
	Baku	17–30–04	7200		
	Helsingfors	17–30–18	8480		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
April 27 2789	Tachkent	19–16–22	6340	ϕ = 33°·3 N	Irkutsk gives
	Ekaterinburg	19–16–23	6600	λ = 145°·5 E	ϕ = 33°·7 N
	Pulkovo	19–16–20	8200	O = 19–16–22	λ = 143°·4 E
	Strasbourg	19–16–35	9700		
	Uccle	19–16–24	9850		
	Wien	19–16–22	9620		
	Kucino	19–16–23	8020		
	Jinsen	19–16–18	1590		
	Leningrad	19–16–20	8200		
	Makéevka	19–16–22	8440		
	Baku	19–16–20	8080		
	Irkutsk	19–16–13	3720		
	Tiflis	19–16–20	8350		
May 9 2798	Belgrade	10–31–53	3470	ϕ = 31° N	Strasbourg gives
	Cartuja	10–31–46	5620	λ = 57° E	ϕ = 32° N
	Baku	10–31–55	1520	O = 10–31–45	λ = 57°·5 E
	Irkutsk	10–31–36	4740		
	Helwan	10–31–42	2480		
	Leningrad	10–31–45	3950		
	Copenhagen	10–31–41	4600		
	Paris	10–31–47	5020		
	Pulkovo	10–31–44	3920		
	Stonyhurst	10–31–51	5440		
	Strasbourg	10–31–41	4660		
	Uccle	10–31–44	4960		
	Wien	10–31–32	4140		
	Zürich	10–31–46	4520		
	Graz	10–31–56	4000		
	Richmond	10–31–44	5310		
	Agram	10–31–39	4040		
	Kucino	10–31–48	3290		
	Malaga	10–31–38	5780		
	Almeria	10–31–39	5600		
	Toledo	10–31–49	5550		
	Helsingfors	10–31–41	4220		
	Ravensburg	10–31–51	4400		
May 9 2799	Ottawa	20–05–06	4020	ϕ = 14° N	LaPaz gives
	Berkeley	20–05–30	3840	λ = 93° W	ϕ = 18° N
	Cartuja	20–05–29	9350	O = 20–05–36	λ = 93° W
	Hamburg	20–05–49	9420		
	LaPaz	20–05–44	4320		
	Paris	20–05–53	9060		
	Pulkovo	20–05–46	10120		
	Strasbourg	20–05–53	9300		
	Victoria	20–06–38	4650		
	Toledo	20–05–57	8680		
	Almeria	20–05–54	8840		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
May 13 2804	Ekaterinburg	23–09–24	9540	ϕ = 7° N	
	Pulkovo	23–09–22	10960	λ = 151° E	
	Taihoku	23–09–16	3810	O = 23–09–18	
	Kucino	23–09–05	11050	Location approximate	
	Irkutsk	23–09–16	7140		
	Tachkent	23–09–24	8700		
May 15 2805	Algiers	2–47–14	1700	ϕ = 43°·0 N	Leningrad gives
	Barcelona	2–47–28	1440	λ = 20°·4 E	ϕ = 44° 33′ N
	Belgrade	2–47–15	70	O = 2–47–13	λ = 20° 11′ E
	Cartuja	2–47–28	2030		
	Makéeva	2–46–54	1580		Strasbourg gives
	Copenhagen	2–47–16	1380		ϕ = 44° N
	Leningrad	2–47–15	1840		λ = 20°·5 E
	Ekaterinburg	2–47–13	3000		
	Hamburg	2–47–24	1250		
	Helwan	2–47–18	1770		
	Graz	2–47–01	620		
	Paris	2–47–17	1460		
	Pulkovo	2–47–14	1830		
	San Fernando	2–47–06	2460		
	Richmond	2–47–08	1830		
	Strasbourg	2–47–09	1130		
	Tachkent	2–47–07	3840		
	Uccle	2–47–09	1460		
	Agram	2–46–58	550		
	Firenze	2–47–25	730		
	Ravensburg	2–47–13	980		
	Hohenheim	2–47–14	1010		
	Karlsruhe	2–47–00	1200		
	Helsingfors	2–47–34	1650		
	Toledo	2–47–11	2100		
	Alicante	2–47–18	2100		
	Almeria	2–47–13	2110		
	Malaga	2–47–04	2360		
May 16 2806	Baku	12–01–12	8100	ϕ = 31°·5 N	
	Ekaterinburg	12–01–07	6710	λ = 143°·7 E	
	Hamburg	12–01–18	9430	O = 12–01–09	
	Pulkovo	12–01–15	8180		
	Wien	12–01–04	9750		
	Zi-ka-wei	12–00–52	2080		
	Richmond	12–01–13	10050		
	Kucino	12–01–14	8030		
	Leningrad	12–01–13	8190		
	Makéevka	12–01–11	8480		
	Copenhagen	12–01–10	9240		
	Tachkent	12–01–05	6480		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
May 22	Algiers	22-32-42	8520	ϕ = 37°·0 N	Strasbourg gives
2811	Barcelona	22-32-39	8300	λ = 102°·5 E	ϕ = 37°·5 N
	Batavia	22-32-29	4900	O = 22-32-40	λ = 102° E
	Belgrade	22-32-32	6820		
	Cartuja	22-32-39	8980		Sydney gives
	Irkutsk	22-32-52	1570		ϕ = 36° N
	Nagoya	22-32-39	3050		λ = 106° E
	Jinsen	22-32-42	2120		
	Ekaterinburg	22-32-45	3540		Uccle gives
	Leningrad	22-32-40	5480		ϕ = 37° N
	Kobe	22-32-25	2990		λ = 104° E
	Hamburg	22-32-38	7020		
	Helwan	22-32-39	6500		USCGS gives
	Makéevka	22-32-18	5500		ϕ = 36° N
	Sumoto	22-32-45	2820		λ = 102° E
	Zürich	22-32-34	7550		
	Toledo	22-32-49	8620		St. Louis gives
	Reykjavik	22-31-52	7920		ϕ = 36°·5 N
	Toyooka	22-32-44	2810		λ = 100° E
	Jena	22-32-38	7080		
	Graz	22-32-30	7150		
	Lick	22-32-57	10450		
	Taihoku	22-32-58	2230		
	Almeria	22-32-42	8950		
	Paris	22-32-37	7850		
	Nagasaki	22-33-18	2590		
	Pulkovo	22-32-39	5460		
	Perth	22-32-39	8000		
	Sydney	22-33-01	9250		
	San Fernando	22-32-57	8900		
	Karlsruhe	22-33-01	7040		
	Uccle	22-32-40	7500		
	Victoria	22-32-45	9500		
	Wien	22-32-21	7120		
	Zi-ka-wei	22-32-47	1850		
	Saskatoon		9340		
	Ste. Anne	22-32-47	10350		
	Richmond	22-32-57	7460		
	Agram	22-32-34	7110		
	Firenze	22-32-06	7950		
	Hohenheim	22-32-44	7280		
	Helsingfors	22-32-38	5780		
	Frankfurt	22-32-26	7450		
May 23	Ekaterinburg	13-51-14	3520	ϕ = 38° N	
2812	Pulkovo	13-51-10	5440	λ = 102°·5 E	
	Zi-ka-wei	13-51-07	1990	O = 13-51-11	
	Tiflis	13-51-11	4780		
	Irkutsk	13-51-15	1630		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
June 2	Cartuja	16–37–22	8260	ϕ = 25°·5 N	Ekaterinburg gives
2817	Ekaterinburg	16–37–29	3920	λ = 84°·5 E	ϕ = 24° 58′ N
	Uccle	16–37–26	7200	O = 16–37–27	λ = 81° 48′ E
	Tiflis	16–37–12	3940		
	Baku	16–37–11	3590		
	Irkutsk	16–37–38	3440		
	Makéevka	16–37–32	4500		
	Tachkent	16–37–42	2150		
	Leningrad	16–37–30	5560		
	Kucino	16–37–25	4920		
	Almeria	16–37–28	8080		
June 3	Irkutsk	7–11–55	7060	ϕ = 8° S	Sydney gives
2818	Perth	7–12–02	3050	λ = 131° E	ϕ = 8° S
	Tachkent	7–11–57	8280	O = 7–12–02	λ = 129° E
	Sydney	7–11–54	3520		
	Zi-ka-wei	7–12–09	4040		
	Sydney Observatory	7–12–21	3330		
	Apia	7–11–55	6540		
June 5	Barcelona	8–25–13	2320	ϕ = 36° N	Strasbourg gives
2819	Belgrade	8–24–55	1230	λ = 30°·7 E	ϕ = 39°·5 N
	Baku	8–24–54	1750	O = 8–24–50	λ = 34° E
	Ekaterinburg	8–24–55	3020		
	Hamburg	8–24–49	2510		
	Helwan	8–25–07	580		
	Leningrad	8–24–53	2580		
	Kucino	8–24–54	2180		
	Paris	8–24–51	2640		
	Pulkovo	8–24–54	2560		
	Strasbourg	8–24–48	2350		
	Uccle	8–24–51	2610		
	Wien	8–24–01	2270		
	Zürich	8–24–43	2300		
	Ravensburg	8–24–37	2290		
	Richmond	8–24–54	2850		
	Helsingfors	8–24–42	2730		
	Toledo	8–24–52	2960		
	Almeria	8–24–50	2950		
	Malaga	8–24–58	2950		
	Agram	8–25–03	2110		
	Firenze	8–24–44	1990		
	Graz	8–24–40	1890		
	Tachkent	8–24–55	3140		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
June 10	Cartuja	17-08-22	8930	ϕ = 2° S	LaPaz gives
2823	LaPaz	17-08-16	2050	λ = 80° W	ϕ = 2° S
	La Plata	17-08·3	4120	O = 17-08-19	λ = 80°·5 W
	Richmond	17-08-32	9230		
	Almeria	17-08-20	9060		
	Sucre	17-08-06	2510		
June 11	Batavia	2-31-45	2860	ϕ = 2° S	
2824	Perth	2-31-47	3800	λ = 132°·5E	
	Kucino	2-32·6	10330	O = 2-32-06	
	Tiflis	2-32-15	9640		
	Baku	2-31-59	9620		
	Tachkent	2-32-14	7740		
June 14	Pulkovo	4-02-22	7100	ϕ = 44° N	
2827	Zi-ka-wei	4-02-12	2650	λ = 147° E	
	Baku	4-02-17	7660	O = 4-02-16	
	Tachkent	4-02-15	6140		
June 20	Pulkovo	14-15-45	6710	ϕ = 55° N	
2835	Kucino	14-15-27	7100	λ = 171° E	
	Baku	14-15-09	7980	O = 14-15-25	
	Makéevka	14-15-20	7750		
June 26	Algiers	11-20-39	2730	ϕ = 44°·2 N	Strasbourg gives
2839	Barcelona	11-20-43	2620	λ = 33°·5 E	ϕ = 45° N
	Belgrade	11-20-56	1010	O = 11-20-48	λ = 34° E
	Cartuja	11-20-44	3150		
	Baku	11-20-49	1410		Zürich gives
	Makéevka	11-20-46	520		ϕ = 42°·9 N
	Ekaterinburg	11-20-48	2230		λ = 33°.3 E
	Hamburg	11-20-49	2000		
	Helwan	11-20-59	1530		
	Copenhagen	11-21-02	1810		
	Graz	11-21-04	1360		
	Leningrad	11-21-07	1540		
	Tachkent	11-20-41	2820		
	Paris	11-20-58	2350		
	Pulkovo	11-21-06	1530		
	Strasbourg	11-20-43	2080		
	Uccle	11-20-43	2360		
	Wien	11-20-33	1510		
	Zürich	11-20-44	2030		
	Ravensburg	11-20-39	1920		
	Hohenheim	11-20-28	2080		
	Karlsruhe	11-20-47	2100		
	Helsingfors	11-21-01	1650		
	Richmond	11-20-41	2660		
	Toledo	11-20-43	3030		
	Malaga	11-21-07	3020		
	Firenze	11-20-31	1970		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
June 30	Baku..............	22–59–32	2610	ϕ = 38° N	
2844	Hamburg...........	22–59–29	1950	λ = 22° E	
	Leningrad..........	22–59–33	2610	O = 22–59–42	
	Tachkent...........	22–59–36	4020		
	Paris..............	22–59–47	1810		
	Pulkovo............	22–59–44	2350		
	Uccle..............	22–59–47	1810		
	Wien...............	22–59–21	1500		
	Zürich.............	22–59–29	1470		
	Hohenheim..........	22–59–20	1620		
	Richmond...........	23–00–01	2180		
	Helsingfors........	22–59·6	2440		
	Toledo.............	23–00–16	1920		
	Almeria............	23–00–11	1980		
	Alicante...........	23–00–21	1910		
	Kucino.............	22–59–26	2450		
	Tiflis.............	22–59–36	2210		
	Copenhagen.........	22–59–40	1980		
July 1	Ottawa.............	8–19–03	7750	ϕ = 36°·0 N	Strasbourg gives
2845	Algiers............	8–19–12	1630	λ = 22°·2 E	ϕ = 36°·5 N
	Barcelona..........	8–18–55	1850	O = 8–19–00	λ = 22°·5 E
	Belgrade...........	8–18–50	950		
	Besançon...........	8–19–20	1610		Uccle gives
	Cartuja............	8–18–51	2340		ϕ = 35°·5 N
	Baku...............	8–18–55	2370		λ = 20 °E
	Irkutsk............	8–18–57	6250		
	Ekaterinburg.......	8–18–46	3320		
	Fordham............	8–19–36	7560		
	Hamburg............	8–18–57	2090		
	Helwan.............	8–19–17	920		
	Ithaca.............	8–19–03	7820		
	Lemberg............	8–18–46	1570		
	Makéevka...........	8–18–58	1760		
	Tachkent...........	8–19–03	3690		
	Jena...............	8–19–17	1690		
	Kucino.............	8–18–56	2340		
	Osaka..............	8–19–06	9400		
	Paris..............	8–18–58	2080		
	Pulkovo............	8–19–01	2500		
	San Fernando.......	8–19–04	2440		
	Alicante...........	8–19–09	1940		
	Toledo.............	8–18–57	2300		
	Almeria............	8–18–58	2180		
	Malaga.............	8–18–55	2370		
	Stonyhurst.........	8–19–03	2580		
	Strasbourg.........	8–18–58	1780		
	Uccle..............	8–18–56	2120		
	Wien...............	8–18–49	1420		
	Zi-ka-wei..........	8–19–16	8400		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
July 1 2845	Graz	8-18-53	1300		
	Zürich	8-18-53	1680		
	Hohenheim	8-18-56	1730		
	Richmond	8-18-51	2440		
	Helsingfors	8-18-52	2590		
	Frankfurt	8-18·8	1970		
	Karlsruhe	8-18-49	1850		
July 6 2849	Cartuja	0-03-43	2870	ϕ = 52°·5 N	
	Ekaterinburg	0-03-38	5540	λ = 33°·3 W	
	Uccle	0-03-40	2590	O = 0-03-43	
	Richmond	0-03-50	2210		
July 7 2851	Algiers	20-06-16	5550	ϕ = 28° N	Zurich gives
	Besançon	20-06-28	5160	λ = 62° E	ϕ = 25° N
	Cartuja	20-06-25	6120	O = 20-06-23	λ = 60° E
	Hamburg	20-06-17	5100		
	Helwan	20-06-17	2960		
	Naples	20-06-34	4220		
	Paris	20-06-21	5530		
	Stonyhurst	20-06-34	5750		
	Strasbourg	20-06-22	5080		
	Uccle	20-06-22	5400		
	Wien	20-06-39	4180		
	Zürich	20-06-20	5050		
	Richmond	20-06-25	5720		
	Toledo	20-06-29	6040		
	Almeria	20-06-29	5960		
	Baku	20-05-58	2110		
	Irkutsk	20-06-20	4360		
	Kucino	20-06-22	3540		
	Makéevka	20-06-21	3020		
	Tachkent	20-06-31	1670		
July 11 2855	Ekaterinburg	8-08-17	5720	ϕ = 42°·5 N	
	Pulkovo	8-08-28	7100	λ = 142°·5 E	
	Victoria	8-08-51	6720	O = 8-08-23	
	Zi-ka-wei	8-07-56	2400		
	Nagoya	8-08-27	870		
	Irkutsk	8-08-23	2930		
	Tachkent	8-08-20	5820		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
July 11	Algiers	13-03-41	3140	ϕ = 31°·7 N	Cartuja gives
2856	Barcelona	13-03-23	3410	λ = 35°·8 E	ϕ = 31°·4 N
	Belgrade	13-03-59	1990	O = 13-03-53	λ = 35°·2 E
	Besançon	13-04-06	2890		
	Cartuja	13-03-52	3590		Strasbourg gives
	Tiflis	13-04-00	1440		ϕ = 32° N
	Baku	13-04-01	1660		λ = 35°·5 E
	Ekaterinburg	13-03-56	3270		
	Helwan	13-03-59	520		
	Lemberg	13-04-11	2180		
	Irkutsk	13-04-01	5860		
	Makéevka	13-04-08	1780		
	Naples	13-04-15	2110		
	Paris	13-03-55	3250		
	Tachkent	13-03-55	3110		
	Pulkovo	13-04-01	3000		
	Stonyhurst	13-03-56	3750		
	Strasbourg	13-03-50	2990		
	Jena	13-03-55	2880		
	Uccle	13-04-02	3150		
	Wien	13-03-56	2460		
	Zi-ka-wei	13-04-03	7990		
	Zürich	13-03-26	3170		
	Richmond	13-03-44	3690		
	Karlsruhe	13-03-34	3190		
	Ravensburg	13-03-34	2990		
	Hohenheim	13-03-37	3070		
	Firenze	13-03-54	2590		
	Graz	13-03-55	2450		
	Almeria	13-03-44	3600		
	Malaga	13-04-03	3550		
	Alicante	13-03-51	3440		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
July 12	Ottawa	21-08-08	8940	ϕ = 46°·3 N	
2857	Irkutsk	21-07-56	2930	λ = 145°·7 E	
	Besançon	21-08-04	8880	O = 21-08-00	
	Cartuja	21-08-00	10060		
	Tiflis		7540		
	Baku	21-08-00	7300		
	Ekaterinburg	21-07-57	5520		
	Hamburg	21-08-02	8200		
	Makéevka	21-07-59	7460		
	Kucino	21-08-00	6820		
	Naples	21-08-17	9000		
	Jena	21-08-06	8340		
	Paris	21-08-07	8820		
	Tachkent	21-07-54	5880		
	Pulkovo	21-08-01	6860		
	Kobe	21-07-48	1440		
	Sumoto	21-07-04	1510		
	Strasbourg	21-08-01	8740		
	Toronto	21-08-05	8980		
	Uccle	21-08-03	8610		
	Victoria	21-08-08	6240		
	Wien	21-08-01	8480		
	Zi-ka-wei	21-07-47	2520		
	Zürich	21-08-05	8780		
	Richmond	21-08-02	8720		
	Spokane	21-08-06	6460		
	Helingfors	21-08-00	7080		
	Nagassaki	21-07-55	1840		
	Agram	21-08-03	8680		
	Jinsen		1670		
	Firenze		8200		
	Graz	21-08-04	8550		
July 14	Ottawa	23-27-35	6050	ϕ = 9° S	LaPaz gives
2859	LaPaz	23-27-29	1810	λ = 83° W	ϕ = 16°·2 S
	Toronto	23-27-36	5750	O = 23-27-42	λ = 85° W
	Victoria	23-27-31	7800	Location approximate	
	Sucre	23-27-50	2035		
	Toledo	23-27-57	9400		
	Malaga	23-27-56	9350		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
July 22 2866	Algiers	3-54-43	4620	ϕ = 36°·0 N	
	Belgrade	3-53-57	3520	λ = 55°·5 E	
	Besançon	3-54-42	4380	O = 3-54-53	
	Cartuja	3-54-43	5360		
	Baku	3-55-02	840		
	Irkutsk	3-55-02	4340		
	Ekaterinburg	3-55-25	2320		
	Hamburg	3-55-01	3950		
	Helwan	3-54-45	2360		
	Tachkent	3-55-00	1600		
	Lemberg	3-55-00	2990		
	Kucino	3-54-46	2850		
	Makéevka	3-54-59	2110		
	Osaka		6660		
	Paris	3-55-01	4400		
	Pulkovo	3-55-04	3180		
	Stonyhurst	3-55-02	4800		
	Strasbourg	3-54-46	4180		
	Uccle	3-55-02	4280		
	Richmond	3-54-59	4670		
	Helsingfors	3-55·1	3290		
	Karlsruhe	3-55-05	3920		
	Jinsen	3-54-30	6700		
	Firenze	3-55-08	3600		
	Graz	3-55-00	3410		
	Toledo	3-55-02	5050		
	Almeria	3-54-43	5280		
	Malaga	3-54-37	5600		
	Alicante	3-54-37	5390		
July 22 2867	Ekaterinburg	8-37-26	2580	ϕ = 33° N	
	Helwan	8-37-15	2390	λ = 54° E	
	Pulkovo	8-37-20	3400	O = 8-37-23	
	Makéevka	8-37-43	2000	Location approximate	
	Tachkent	8-37-09	1770		
July 23 2868	Cartuja	20-17-45	5270	ϕ = 34° N	
	Ekaterinburg	20-17-50	2560	λ = 55°·2 E	
	Makéevka	20-18-04	2010	O = 20-17-52	
	Helwan	20-17-46	2300		
	Pulkovo	20-18-02	3140		
	Kucino	20-17-54	2660		
	Stonyhurst	20-17-40	4980		
	Uccle	20-17-51	4310		
	Richmond	20-17-56	4600		
	Helsingfors	20-17-53	3420		
	Firenze	20-18-10	3620		
	Toledo	20-17-42	5220		
	Almeria	20-17-46	5100		
	Baku	20-17-47	890		
	Irkutsk	20-17-55	4380		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
July 23	Besançon..........	22–40–11	4320	ϕ = 35° N	
2869	Ekaterinburg........	22–40–22	2560	λ = 55°·2 E	
	Helwan............	22–40–19	2300	O = 22–40–21	
	Paris............	22–40–13	4560		
	Pulkovo..........	22–40–29	3170		
	Stonyhurst..........	22–40–20	4860		
	Uccle............	22–40–23	4300		
	Zi-ka-wei..........	22–40–27	6270		
	Richmond..........	22–40–26	4600		
	Helsingfors.........	22–40–20	3440		
	Almeria..........	22–40–19	5090		
	Baku............	22–40–09	960		
	Kucino............	22–40–28	2650		
	Makéevka..........	22–40–31	2030		
July 28	Ottawa............	16–17–43	5560	ϕ = 54° N	
2871	Algiers............	16–17–51	9590	λ = 158°·5 W	
	Kucino............	16–17–50	7620	O = 16–17–46	
	Tachkent..........	16–17–50	8450		
	Ekaterinburg........	16–17–44	7140		
	Fordham..........		6110		
	Hamburg..........	16–17–43	8050		
	Ithaca............	16–17–57	5580		
	Lick............	16–18–12	3070		
	Naples............	16–17–57	9500		
	Paris............	16–17–39	8620		
	Pulkovo..........	16–17–48	7240		
	Stonyhurst..........	16–17–55	7700		
	Strasbourg..........	16–17–39	8650		
	Toronto..........	16–17–42	5480		
	Wien............	16–17–06	9450		
	Zi-ka-wei..........	16–17–46	6640		
	St. Louis..........	16–17–22	5150		
	Richmond..........	16–17–49	8050		
	Spokane..........	16–17–35	2860		
	Firenze..........	16–18–10	8680		
	Apia............	16–18–11	7600		
	Toledo............	16–17–51	9200		
	Almeria..........	16–17–51	9510		
	Irkutsk..........	16–17–27	6140		
July 29	Cartuja..........	0–02–44	9780	ϕ = 15° N	
2872	Ekaterinburg........	0–03–07	5140	λ = 89° E	
	Pulkovo..........	0–03–11	6800	O = 0–03–13	
	Uccle............	0–03–17	8260	Location approximate	
	Wien............	0–03–08	7500		
	Richmond..........	0–03–17	8550		
	Agram............	0–03–42	6920		
	Malaga............	0–03–18	9120		
	Irkutsk............	0–03–10	4320		
	Kucino............	0–03–08	6200		
	Tachkent..........	0–03–22	3160		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
July 30 2875	Ekaterinburg Pulkovo Zi-ka-wei Nagoya Tachkent Kucino	14–18–27 14–18–25 14–18–28 14–18–33 14–18–24	5960 7560 1860 350 5940 7440	ϕ = 37° N λ = 141° E O = 14–18–27	
Aug. 1 2879	Ekaterinburg Pulkovo Tachkent	17–05–57 17–06–07 17–06–10	6900 7340 7700	ϕ = 51° N λ = 180° W O = 17–06–04	
Aug. 1 2880	Ekaterinburg Pulkovo Makéevka Tachkent	18–46–17 18–46–24 18–46–27 18–46–25	6940 7420 8440 7900	ϕ = 51° N λ = 176° W O = 18–46–23	
Aug. 4 2885	Batavia Ekaterinburg Pulkovo Zi-ka-wei Baku Tachkent	15–47–43 15–47–57 15–47–25 15–47–57 15–47–57 15–47–57	1900 8250 10380 3520 8480 7060	ϕ = 0°·7 S λ = 123° E O = 15–47–49	
Aug. 5 2888	Cartuja LaPaz Sucre	3–43–12 3–43–16 3–43–01	9380 2540 3040	ϕ = 1°.5 S λ = 85°·5 W O = 3–43–10	Sucre gives ϕ = 0° λ = 84° W

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 5 2889	Ottawa	21-13-04	9750	ϕ = 38°·6 N	Richmond gives
	Algiers	21-13-18	10100	λ = 142° E	ϕ = 40° N
	Belgrade	21-12-59	9080	O = 21-13-02	λ = 141° E
	Baku	21-12-57	7580		
	Irkutsk	21-12-49	3200		
	Ekaterinburg	21-12-49	6080		
	Fordham	21-13-08	10100		
	Hamburg	21-12-53	8950		
	Helwan	21-13-17	9160		
	Ithaca	21-13-13	9880		
	Lemberg	21-12·8	8550		
	Makéevka	21-12-48	8060		
	Tachkent	21-12-53	6020		
	Toyooka	21-13-03	660		
	Manila	21-13-06	3040		
	Paris	21-13-14	9220		
	Pulkovo	21-12-54	7530		
	San Fernando	21-13-12	10020		
	Stonyhurst	21-13-10	9100		
	Strasbourg	21-13-05	9210		
	Richmond	21-13-10	9170		
	Toronto	21-13-06	9800		
	Uccle	21-13-00	9220		
	Victoria	21-13-07	7150		
	Wien	21-12-52	9120		
	Zi-ka-wei	21-13-00	1970		
	Karlsruhe	21-13-09	9160		
	Agram	21-13-00	9160		
	Jinsen	21-13-03	1330		
	Firenze	21-13-02	9350		
	Nagasaki	21-12-57	1230		
Aug. 6 2890	Ottawa	0-14-00	5500	ϕ = 54°·8 N	
	Algiers	0-14-15	9300	λ = 157° W	
	Cartuja	0-13-56	9520	O = 0-14-00	
	Ekaterinburg	0-14-02	7000		
	Fordham	0-13-47	6080		
	Paris	0-14-02	8350		
	Pulkovo	0-13-59	7220		
	Strasbourg	0-14-05	8380		
	Toronto	0-13-55	5440		
	Uccle	0-14-01	8160		
	Zi-ka-wei	0-13-53	6680		
	Zürich	0-14-05	8500		
	Richmond	0-13-59	8050		
	Firenze	0-13-58	9080		
	Toledo	0-14-04	9130		
	Almeria	0-13-55	9520		
	Malaga	0-14-16	9350		
	Makéevka	0-14-10	8320		
	Tachkent	0-13-53	8600		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 8 2892	Pulkovo	0–25–13	1940	ϕ = 73° N	
	Uccle	0–25–35	2450	λ = 5° E	
	Makéevka	0–25–24	3180	O = 0–25–24	
Aug. 8 2893	Ekaterinburg	0–57–42	5700	ϕ = 53° N	
	Pulkovo	0–57–51	6670	λ = 158° E	
	Agram	0–57–59	8450	O = 0–57–52	
	Baku	0–57–52	7560		
	Makéevka	0–57–54	7420		
Aug. 10 2898	Ottawa	1–35–18	4200	ϕ = 7°·0 N	La Paz gives
	Algiers	1–35–39	9020	λ = 81°·6 W	ϕ = 6°·7 N
	Barcelona	1–35–51	8840	O = 1–35–30	λ = 81°·0 W
	Berkeley	1–35–15	5300		
	Cartuja	1–35–31	8640		
	Hamburg	1–35–36	9400		
	Ithaca	1–35–24	3820		
	LaPaz	1–35–14	3070		
	Paris	1–35–33	9000		
	San Fernando	1–35–48	8250		
	Strasbourg	1–35–31	9380		
	Toronto	1–35–17	3920		
	Uccle	1–35–31	9170		
	Victoria	1–35–14	6070		
	Zürich	1–35–35	9400		
	Halifax	1–35–21	4550		
	St. Louis	1–35–32	3360		
	Richmond	1–35–31	8850		
	La Plata	1–34·7	5100		
	Agram	1–35–54	9480		
	Hohenheim	1–35–40	9350		
	Sucre	1–35–28	3300		
	Firenze	1–35–57	9400		
	Toledo	1–35–29	8600		
	Almeria	1–35–32	8700		
	Alicante	1–35–46	8840		
Aug. 10 2900	Batavia	11–36–20	2590	ϕ = 2° S	
	Irkutsk	11–36–06	6440	λ = 130° E	
	Ekaterinburg	11–36–18	8800	O = 11–36–11	
	Toyooka	11–36–04	3850		
	Manila	11–35–53	2230		
	Kucino	11–36–07	10220		
	Makéevka	11–36–10	10250		
	Wellington	11–36–14	6180		
	Pulkovo	11–36–09	10540		
	Strasbourg	11–36–27	11950		
	Zi-ka-wei	11–36–18	3410		
	Sydney Observatory	11–36–15	4120		
	Nagoya	11–36–06	3820		
	Apia	11–36–13	6480		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 12 2903	Ekaterinburg........	0–33–41	6100	ϕ = 36° N	
	Pulkovo............	0–33–45	7540	λ = 140° E	
	Jinsen..............	0–33–47	1450	O = 0–33–45	
	Nagasaki...........	0–33–51	1030	Location approximate	
	Baku...............	0–33–44	7320		
Aug. 12 2904	Ekaterinburg........	10–22–47	1920	ϕ = 40° N	
	Pulkovo............	10–22–33	3500	λ = 72°·5 E	
	Baku...............	10–22–47	1850	O = 10–22–38	
	Irkutsk............	10–22–35	2800		
	Kucino.............	10–22–33	2980		
	Makéevka...........	10–22–31	2850		
Aug. 18 2905	Baku...............	19–27–48	7940	ϕ = 36° N	
	Ekaterinburg........	19–27–50	6280	λ = 144° E	
	Hamburg............	19–27–53	9250	O = 19–27–50	
	Helwan.............	19–28–16	9320		
	Makéevka...........	19–27–52	8220		
	Paris..............	19–27–55	9800		
	Pulkovo............	19–27–56	7820		
	Strasbourg.........	19–27–59	9500		
	Uccle..............	19–27–58	9480		
	Victoria...........	19–28–05	7500		
	Wien...............	19–27–56	9320		
	Zi-ka-wei..........	19–27–11	2230		
	Zürich.............	19–28–08	9460		
	Nagoya.............	19–28–10	750		
	Jinsen.............	19–27–35	1520		
	Nagasaki...........	19–26–54	1440		
	Sumoto.............	19–27–44	700		
Aug. 20 2906	Ekaterinburg........	23–16–49	6320	ϕ = 36° N	
	Pulkovo............	23–17–03	7750	λ = 145° E	
	Tachkent...........	23–16–33	6340	O = 23–16–48	
Aug. 20 2908	Ekaterinburg........	21–37–18	6370	ϕ = 34° N	
	Pulkovo............	21–37–20	7900	λ = 144°·5 E	
	Baku...............	21–37–23	7880	O = 21–37–18	
	Makéevka...........	21–37–12	8320		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 20 2909	Ottawa	23-54-23	4370	ϕ = 6°·3 N	LaPaz gives
	Barcelona	23-54-39	9050	λ = 83°·0 W	ϕ = 4°·7N
	Cartuja	23-54-16	8850	O = 23-54-28	λ = 83°·0 W
	Hamburg	23-54-46	9320		
	LaPaz	23-54-00	3000		La Plata gives
	Alicante	23-54-33	8840		ϕ = 0°·5 S
	Malaga	23-54-38	8520		λ = 89°·5 W
	Almeria	23-54-30	8820		
	Toledo	23-54-28	8680		
	San Fernando	23-54-42	8380		
	Paris	23-54-34	9120		
	Sucre	23-54-07	3290		
	Strasbourg	23-54-41	9230		
	Toronto	23-54-22	4140		
	Uccle	23-54-29	9310		
	Victoria	23-54-14	6350		
	Wien	23-54-28	10150		
	St. Louis	23-54-22	3660		
	Richmond	23-54-38	8900		
	Firenze	23-54-47	9600		
	Hohenheim	23-54-57	9400		
	Zürich	23-54-17	9620		
	La Plata	23-53·3	5100		
	Ravensburg	23-54-56	9350		
Aug. 21 2910	Cartuja	10-19-19	8600	ϕ = 6° N	La Plata gives
	LaPaz	10-18-59	2890	λ = 83 °W	ϕ = 0°
	Victoria	10-19-23	6070	O = 10-19ca.	λ = 89° W
	La Plata	10-18·0	5100		
	Malaga	10-19-19	8550		
	Sucre	10-18-40	3370		
Aug. 23 2914	Ekaterinburg	6-28-57	6370	ϕ = 35° N	
	Manila	6-28-57	3650	λ = 144° E	
	Pulkovo	6-29-03	7820	O = 6-28-54	
	Victoria	6-29-25	7320		
	Zi-ka-wei	6-28-40	2090		
	Nagoya	6-28-44	640		
	Jinsen	6-28-36	1550		
	Toyooka	6-28-41	800		
	Baku	6-29-01	7860		
	Kucino	6-29-15	7780		
	Makéevka	6-28-39	8400		
	Tachkent	6-28-46	6370		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Aug. 24 2915	Ekaterinburg	8-55-57	6260	ϕ = 39° N	
	Pulkovo	8-56-06	7680	λ = 147° E	
	Strasbourg	8-56-02	9380	O = 8-56-00	
	Victoria		6820		
	Wien	8-56-34	8820		
	Zi-ka-wei	8-55-25	2380		
	Baku	8-56-02	7800		
	Makéevka	8-56-03	8060		
	Tachkent	8-55-53	6250		
Sept. 3 2921	Ottawa	19-47-38	4880	ϕ = 10°·7 N	Sucre gives
	Algiers	19-47-46	5380	λ = 43°·3 W	ϕ = 10°·2 N
	Almeria	19-47-38	4980	O = 19-47-40	λ = 44° W
	Baku	19-47-49	9500		
	Barcelona	19-47-43	5530		
	Cartuja	19-47-36	4960		
	Chicago (L)	19-47-41	5500		
	Ekaterinburg	19-48-08	9400		
	Firenze	19-47-46	6400		
	Fordham	19-47-22	4400		
	Hamburg	19-47-43	6710		
	Helwan	19-47-51	7950		
	Ithaca	19-47-33	4720		
	Karlsruhe	19-47-45	6340		
	Kucino	19-47-46	8580		
	LaPaz	19-47-39	3980		
	La Plata	19-46·7	5220		
	Malaga	19-47-33	4860		
	Paris	19-47-41	5960		
	Pulkovo	19-47-50	8080		
	Ravensburg	19-47-39	6450		
	Richmond	19-47-40	5950		
	San Fernando	19-47-32	4720		
	Stonyhurst	19-47-35	6110		
	Strasbourg	19-47-37	6390		
	Sucre	19-47-41	3960		
	Tachkent	19-47-40	11000		
	Toledo	19-47-41	4960		
	Toronto	19-47-35	4960		
	Uccle	19-47-40	6220		
	Victoria	19-47-52	8400		
	Wien	19-48-00	6620		
	Zurich	19-47-46	6240		
Sept. 8 2928	Batavia	23-22-51	220	ϕ = 6° S	Tachkent gives
	Ekaterinburg	23-22-56	8200	λ = 110° E	ϕ = 9° 6′ S
	Pulkovo	23-22-57	9740	O = 23-22-53	λ = 103° 28′ E
	Baku	23-22-50	7940	Location approximate	
	Makéevka	23-23-00	8900		
	Kucino	23-22-53	9340		
	Tachkent	23-22-47	6600		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Sept. 10	Ekaterinburg........	16–28–16	9960	ϕ = 34° S	
2930	Baku............	16–28–20	8380	λ = 55° E	
	Makéevka..........	16–28–17	9200	O = 16–28–17	
	Tachkent..........	16–28–17	8400	Location doubtful	
Sept. 11	Ottawa.............	22–15–50	7950	ϕ = 44°·5N	Tachkent gives
2931	Algiers............	22–15–41	2690	λ = 34°·5 E	ϕ = 43° 45′ N
	Barcelona..........	22–15–37	2640	O = 22–15–42	λ = 35° 1′ E
	Belgrade...........	22–15–47	1070		
	Cartuja............	22–15–43	3110		Strasbourg gives
	Alicante...........	22–15–40	3030		ϕ = 45° N
	Almeria............	22–15–24	3230		λ = 34°·5 E
	Toledo.............	22–15–23	3230		
	Malaga.............	22–15–25	3360		
	Manila.............	22–16–20	8300		
	Ekaterinburg........	22–15–48	2220		
	Jena...............	22–16–08	1690		
	Helwan.............	22–16–10	1470		
	Ithaca.............	22–15–53	8160		
	Lemberg............	22–15–59	880		
	Ravensburg.........	22–15–34	2035		
	Tachkent...........	22–15–54	2800		
	Osaka..............	22–15–02	8560		
	Paris..............	22–15–49	2400		
	Pulkovo............	22–15–58	1580		
	San Fernando.......	22–15–58	3290		
	Stonyhurst.........	22–15–57	2700		
	Strasbourg.........	22–15–41	2090		
	Toronto............	22–15–47	8260		
	Uccle..............	22–15–32	2430		
	Victoria...........	22–16–00	9350		
	Zi-ka-wei..........	22–15–42	7530		
	Zürich.............	22–15–41	2030		
	Kucino.............	22–15–56	1220		
	Richmond...........	22–15–40	2640		
	Karlsruhe..........	22–15–24	2250		
	Hohenheim..........	22–15–08	2320		
	Firenze............	22–15–27	1990		
	Graz...............	22–15–23	1690		
	Baku...............	22–15–45	1400		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Sept. 12 2932	Algiers	3-19-56	2800	$\phi = 43°{\cdot}8$ N	Tachkent gives
	Almeria	3-20-05	3140	$\lambda = 34°{\cdot}06$ E	$\phi = 43°{\cdot}7$ N
	Baku	3-20-15	1320	O = 3-20-04	$\lambda = 35° 1'$ E
	Belgrade	3-20-03	1120		
	Cartuja	3-20-03	3190		
	Ekaterinburg	3-20-05	2250		
	Firenze	3-19-49	1990		
	Graz	3-20-01	1550		
	Helwan	3-20-30	1550		
	Karlsruhe	3-20-03	2110		
	Kucino	3-20-25	1120		
	Lemberg	3-20-18	900		
	Makéevka	3-20-16	435		
	Paris	3-20-03	2490		
	Pulkovo	3-20-27	1500		
	Ravensburg	3-19-32	2270		
	Richmond	3-19-49	2750		
	Stonyhurst	3-20-06	2770		
	Strasbourg	3-19-51	2190		
	Tachkent	3-20-08	2800		
	Uccle	3-19-51	2460		
	Zürich	3-19-54	2110		
Sept. 12 2933	Baku	6-33-34	1320	$\phi = 46°{\cdot}4$ N	
	Ekaterinburg	6-33-25	2230	$\lambda = 36°{\cdot}5$ E	
	Firenze	6-34-25	2200	O = 6-33-32	
	Kucino	6-33-35	1180		
	Pulkovo	6-33-43	1510		
	Richmond	6-33-15	2730		
	Strasbourg	6-33-17	2140		
	Uccle	6-33-22	2380		
	Zürich	6-33-15	2110		
Sept. 12 2934	Alicante	14-23-46	3160	$\phi = 44°{\cdot}0$ N	
	Almeria	14-23-48	3080	$\lambda = 35°{\cdot}5$ E	
	Belgrade	14-23-39	1210	O = 14-23-55	
	Cartuja	14-23-50	3170		
	Ekaterinburg	14-23-56	2220		
	Firenze	14-23-53	1910		
	Graz	14-24-05	1430		
	Jena	14-24-09	1790		
	Karlsruhe	14-24-08	2020		
	Kucino	14-24-16	1120		
	Lemberg	14-24-10	880		
	Makéevka	14-23-55	480		
	Malaga	14-23-32	3360		
	Paris	14-23-53	2440		
	Pulkovo	14-24-12	1540		
	Richmond	14-23-50	2030		
	Strasbourg	14-23-52	2080		
	Tachkent	14-24-01	2720		
	Uccle	14-23-44	2400		
	Zürich	14-23-50	2030		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Sept. 16 2936	Baku	15–46–38	7760	ϕ = 47°·5 N	
	Paris	15–46–38	9020	λ = 155°·5 E	
	Pulkovo	15–46–34	7100	O = 15–46–34	
	Tachkent	15–46–24	6540		
Sept. 23 2940	Cartuja	13–53–56	7560	ϕ = 47° N	Tachkent gives
	Tachkent	13–53–06	1810	λ = 91° E	ϕ = 41°·1 N
	Alicante	13–54–28	6980	O = 13–54–12	λ = 91°·0 E
	Pulkovo	13–54–15	3910	Location approximate	
	San Fernando	13–54–19	7450		
	Strasbourg	13–54–05	5820		
	Victoria	13–54–58	8900		
	Wien	13–54–02	5240		
	Zi-ka-wei	13–54–13	3360		
	Richmond	13–54–15	6120		
	Jinsen	13–54–13	3470		
	Baku	13–54–24	2720		
	Makéevka	13–54–13	3470		
	Toledo	13–54–18	7020		
	Almeria	13–54–08	7360		
	Malaga	13–54–15	7360		
Sept. 24 2942	Algiers	6–13–47	2750	ϕ = 45°·2 N	
	Belgrade	6–14–12	970	λ = 36°·2 E	
	Cartuja	6–13–33	3330	O = 6–13–54	
	Hamburg	6–13–41	2120		
	Pulkovo	6–14–09	1600		
	Strasbourg	6–13–52	2090		
	Uccle	6–13–51	2390		
	Richmond	6–13–49	2680		
	Frankfurt	6–13–53	2080		
	Firenze	6–14–06	1800		
	Baku	6–13–57	1330		
	Makéevka	6–14–05	440		
	Zagreb	6–14–25	1260		
	Kucino	6–13–07	1170		
	Tachkent	6–13–58	2720		
Sept. 30 2947	Ekaterinburg	7–38–21	5860	ϕ = 38° N	Tachkent gives
	Pulkovo	7–38–05	7640	λ = 147°·5 E	ϕ = 36°·3 N
	Zi-ka-wei	7–37–41	2550	O = 7–38–08	λ = 142°·2 E
	Nagasaki	7–38–00	1750		
	Kobe	7–38–43	870		
	Baku	7–37–56	7980		
	Tachkent	7–38–09	6130		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 2 2949	Ottawa............ Cartuja............ LaPaz............ Toronto............ Sucre............ La Plata............ Victoria............	4-47-58 4-47-58 4-47-24 4-47-59 4-47-27 4-46·7 4-48-38	3530 9070 4210 3200 4380 6240 4220	ϕ = 12° N λ = 92° W O = 4-47-45 Location doubtful	Sucre gives ϕ = 20° N λ = 61° W
Oct. 8 2957	Baku............ Ekaterinburg........ Kucino............ Tachkent............	10-34-26 10-34-28 10-33-57 10-34-39	3050 3290 4560 1590	ϕ = 30°·6 N λ = 82° E O = 10-34-22	
Oct. 8 2958	Baku............ Ekaterinburg........ Tachkent............ Zi-ka-wei............	12-26-09 12-26-11 12-26-06 12-24-54	8100 6650 6450 2080	ϕ = 32°·0 N λ = 143°·5 E O = 12-25-50	
Oct. 11 2963	Ekaterinburg........ Makéevka............ Paris............ Pulkovo............ Tachkent............ Toyooka............ Zagreb............	17-30-24 17-30-23 17-30-30 17-30-24 17-30-17 17-30-38 17-30-36	5620 7500 9010 7020 5800 1040 8680	ϕ = 44° N λ = 143°·5 E O = 17-30-27	

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 24	Algiers	15–59–54	8950	$\phi = 57°$ N	Ekaterinburg gives
2973	Alicante	15–59–40	8920	$\lambda = 136°$ W	$\phi = 55° 24'$ N
	Almeria	15–59–58	8720	O = 15–59–50	$\lambda = 146° 34'$ W
	Baku	15–59–37	9420		
	Barcelona	15–59–26	8950		St. Louis gives
	Cartuja	16–00–05	8600		$\phi = 59°{\cdot}5$ N
	Ekaterinburg	15–59–46	7300		$\lambda = 138°$ W
	Firenze	15–59–46	8540		
	Fordham	15–59–48	4630		
	Frankfurt	15–59–52	7750		
	Graz	15–59–57	8160		
	Hamburg	15–59–57	7320		
	Helwan	16–00–24	9780		
	Hohenheim	15–59–49	8000		
	Ithaca	15–59–59	4280		
	Jinsen	15–59–50	6990		
	Kucino	16–00–49	7460		
	Lemberg	15–59–53	8080		
	Lick	15–59–36	2650		
	Chicago (L)	15–59–51	3720		
	Makéevka	15–59–56	8250		
	Malaga	15–59–47	8720		
	Nagasaki		7390		
	Osaka	16–00–04	6700		
	Ottawa	15–59–36	4260		
	Paris	15–59–57	7650		
	Pulkovo	15–59–51	6900		
	Ravensburg	15–59–55	8000		
	Richmond	15–59–54	7320		
	San Fernando	15–59–55	8700		
	Saskatoon	15–59–31	2050		
	Stonyhurst	15–59–55	6960		
	Strasbourg	15–59–50	7920		
	Sucre	15–59–50	10600		
	Tachkent	15–58–51	8820		
	Toledo	15–59–53	8420		
	Toronto	15–59–44	4120		
	Uccle	15–59–58	7450		
	Wellington	16–00–07	11520		
	Wien	15–59–27	8520		
	Zagreb	15–59–58	8300		
	Zi-ka-wei	16–00–02	7650		
	Zürich	15–59–51	7980		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Oct. 28	Baku	15-23-05	7860	ϕ = 38° N	Ekaterinburg gives
2976	Ekaterinburg	15-23-03	6390	λ = 142°·5 E	ϕ = 26°·8 N
	Pulkovo	15-23-05	7920	O = 15-23-07	λ = 131°·4 E
	Sumoto	15-23-13	580		
	Tachkent	15-23-11	6300		
Oct. 30	Ekaterinburg	3-08-58	3530	ϕ = 73° N	
2977	Pulkovo	3-09-29	2100	λ = 10°·8 W	
	Uccle	3-08-48	2590	O = 3-09-08	
	Tachkent	3-09-16	5300		
Nov. 2	Ekaterinburg	21-06-19	7930	ϕ = 4° S	Ekaterinburg gives
2979	Pulkovo	21-06-09	9560	λ = 105°·7 E	ϕ = 5° 36′ S
	Zi-ka-wei	21-06-16	4260	O = 21-06-12	λ = 102° 56′ E
	Tachkent	21-06-03	6230		
Nov. 4	Ottawa	13-50-47	3910	ϕ = 34°·4 N	Berkeley gives
2980	Algiers	13-51-17	9700	λ = 120°·8 W	ϕ = 34° 32′ N
	Alicante	13-50-53	9640	O = 13-51-00	λ = 121° 24′ W
	Barcelona	13-51-27	9480		
	Belgrade	13-50-55	380		Ekaterinburg gives
	Cartuja	13-50-58	9880		ϕ = 34° 6′ N
	Toledo	13-50-57	9380		λ = 119° 4′ W
	Almeria	13-51-06	9780		
	Ekaterinburg	13-50-58	9850		St. Louis gives
	Hamburg	13-50-51	9340		ϕ = 33° 2′ N
	LaPaz	13-51-02	8000		λ = 122° W
	Malaga	13-51-09	9500		
	Graz	13-51-02	9940		
	Lick	13-50-40	440		
	Sucre	13-50-58	8480		
	Richmond	13-51-00	8940		
	Toyooka	13-51-05	9010		
	Osaka	13-51-27	8580		
	Paris	13-51-07	9200		
	Pulkovo	13-51-05	9220		
	San Fernando	13-50-58	9590		
	Strasbourg	13-51-04	9450		
	Toronto	13-50-55	3500		
	Uccle	13-51-07	9100		
	Wien	13-50-56	9980		
	Zürich	13-51-13	9410		
	Saskatoon	13-50-39	2250		
	Denver	13-51-00	1570		
	St. Louis	13-50-52	2750		
	Firenze	13-50-55	10050		
	Chicago	13-50-49	2960		
	Apia	13-50-56	7780		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 6 2982	Baku	15–34–43	9090	ϕ = 4° S	
	Ekaterinburg	15–34–42	8900	λ = 126° E	
	Zi-ka-wei	15–34–31	3900	O = 15–34–35	
	Tachkent	15–34–24	7860		
Nov. 8 2984	Algiers	3–10–43	9410	$\phi \doteq$ 33° S	Makéevka gives
	Almeria	3–10–22	10160	λ = 57° E	ϕ = 33° 18′ S
	Cartuja	3–10–21	10250	O = 3–10–29	λ = 54° 28′ E
	Ekaterinburg	3–10–36	9940		
	Firenze	3–10–28	9700		
	Graz	3–10–30	9850		
	Helwan	3–10–24	7660		
	Makéevka	3–10–34	9200		
	Malaga	3–10–23	10220		
	Perth	3–10–11	5320		
	Wellington	3–10–43	9230		
	Wien	3–10–32	9850		
	Zagreb	3–10–34	9680		
	Zi-ka-wei	3–10–28	9800		
Nov. 14 2992	Alicante	0–12–06	7310	ϕ = 70° N	Ekaterinburg gives
	Algiers	0–12–07	7370	λ = 126°·7 E	ϕ = 70° 52′ N
	Almeria	0–12–00	7540	O = 0–12–04	λ = 124° 18′ E
	Baku	0–11–57	5470		
	Barcelona	0–12–05	6920		Makéevka gives
	Belgrade	0–12–01	6000		ϕ = 69° 11′ N
	Cartuja	0–12–01	7650		λ = 125° 34′ E
	Cincinnati	0–12–18	7480		
	Ekaterinburg	0–12–11	3280		Pulkovo gives
	Firenze	0–12–04	6400		ϕ = 71° 22′ N
	Graz	0–11–56	6000		λ = 126° 7′ E
	Hamburg	0–12–00	5420		
	Helwan	0–12–11	7100		Strasbourg gives
	Hohenheim	0–12–00	5960		ϕ = 70°·5 N
	Kucino	0–12–15	4210		λ = 121° E
	Malaga	0–12–03	7680		
	Makéevka	0–12–04	5020		St. Louis gives
	Ottawa	0–12–05	7020		ϕ = 71°·6 N
	Paris	0–12–03	6110		λ = 130° E
	Pulkovo	0–12–04	4070		
	Ravensburg	0–11–59	6000		
	Richmond	0–12–01	5890		
	San Fernando	0–12–08	7690		
	Strasbourg	0–12–01	5990		
	St. Louis	0–12–16	7480		
	Toledo	0–12–05	7260		
	Uccle	0–12–04	5810		
	Wien	0–11–48	5870		
	Zürich	0–12–01	6120		
	Zagreb	0–12–04	5990		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 14	Alicante	4-56-41	7360	ϕ = 70°·4 N	Pulkovo gives
2993	Algiers	4-56-29	7370	λ = 128°·0 E	ϕ = 70° 29′ N
	Almeria	4-56-22	7560	O = 4-56-24	λ = 123° 42′ E
	Baku	4-56-04	5580		
	Barcelona	4-56-50	6550		Makéevka gives
	Belgrade	4-56-30	6040		ϕ = 70° 27′ N
	Cartuja	4-56-24	7620		λ = 126° 54′ E
	Ekaterinburg	4-56-27	3330		
	Firenze	4-56-19	6500		
	Graz	4-56-26	5960		
	Hamburg	4-56-13	5520		
	Helwan	4-56-31	7200		
	Hohenheim	4-56-26	5960		
	Innsbruck	4-56-42	5620		
	Kucino	4-56-45	4150		
	Lemberg	4-56·5	5320		
	Malaga	4-56-22	7720		
	Makéevka	4-56-27	5020		
	Osaka	4-54-42	4120		
	Ottawa	4-56-33	6990		
	Paris	4-56-26	6120		
	Pulkovo	4-56-30	4050		
	Ravensburg	4-56-11	6220		
	Richmond	4-56-22	5930		
	San Fernando	4-56-28	7760		
	Strasbourg	4-56-26	5990		
	Toledo	4-56-24	7320		
	Uccle	4-56-30	5750		
	Wien	4-56-36	5480		
	Zürich	4-56-16	6220		
	Zagreb	4-56-27	6040		
Nov. 14	Ottawa	7-19-27	8420	ϕ = 30°·4 S	Sucre gives
2994	Berkeley	7-19-30	9160	λ = 72°·5 W	ϕ = 31°·5 S
	Cartuja	7-19-19	10380	O = 7-19-30	λ = 70° W
	Almeria	7-19-29	10060		
	Malaga	7-19-30	9960		
	Ithaca	7-19-34	8180		
	Alicante	7-19-33	10160		
	Toledo	7-19-37	10000		
	San Fernando	7-19-27	9950		
	Toronto	7-19-24	8200		
	St. Louis	7-19-31	7880		
	La Plata	7-19·6	1180		
	Sucre	7-19-24	1400		
	Wellington	7-19-39	9220		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 15	Berkeley...........	8–29–18	4550	ϕ = 52°·4 N	Ekaterinburg gives
2996	Ekaterinburg........	8–29–25	6680	λ = 179°·7 W	ϕ = 49° 31′ N
	Hamburg...........	8–29–29	8180	O = 8–29–24	λ = 173° 27′ E
	Pulkovo...........	8–29–26	7200		
	Strasbourg..........	8–29–24	8780		Pulkovo gives
	Uccle.............	8–29–28	8500		ϕ = 51° 59′ N
	Zi-ka-wei..........	8–29–11	5150		λ = 175° 31′ E
	Richmond..........	8–29–28	8440		
	St. Louis...........	8–29–39	6370		
	Zürich............	8–29–25	8880		
	Kucino............	8–29–04	7350		
	Baku..............	8–29–26	8640		
Nov. 15	Ekaterinburg........	21–48–50	3270	ϕ = 70° N	Ekaterinburg gives
2997	Hamburg...........	21–48–40	5380	λ = 127° E	ϕ = 70° 54′ N
	Pulkovo...........	21–48–44	4050	O = 21–48–44	λ = 124° 4′ E
	Strasbourg..........	21–48–45	5900		
	Uccle.............	21–48–37	5870		Pulkovo gives
	Tachkent...........	21–48–49	4480		ϕ = 70° 29′ N
	Baku..............	21–48–39	5390		λ = 123° 42′ E
	Makéevka..........	21–48–41	5020		
	Zagreb............	21–48–53	5880		
	Kucino............	21–48–47	4150		
Nov. 16	Batavia............	21–10–05	2620	ϕ = 7°·7 N	Ekaterinburg gives
2998	Ekaterinburg........	21–10–21	7750	λ = 126°·5 E	ϕ = 8° 17′ N
	Baku..............	21–10–13	8260	O = 21–10–12	λ = 127° 54′ E
	Pulkovo...........	21–10–05	9660		
	Wien..............	21–10–29	10250		Pulkovo gives
	Zi-ka-wei..........	21–09–55	2750		ϕ = 7° 58′ N
	Sumoto............	21–10–20	2510		λ = 126° 52′ E
	Kucino............	21–10–11	9160		
	Makéevka..........	21–10–17	9070		
	Tachkent...........	21–10–09	6740		
Nov. 18	Batavia............	3–24–38	8260	ϕ = 11° N	Ekaterinburg gives
3002	Ekaterinburg........	3–24–53	7550	λ = 127° E	ϕ = 11° 27′ N
	Manila............	3–25–02	660	O = 3–24–53	λ = 127° 37′ E
	Pulkovo...........	3–24–50	9220		
	Zi-ka-wei..........	3–24–35	2470		
	Makéevka..........	3–24–48	8940		
	Tachkent...........	3–25–27	6490		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
Nov. 26	Ottawa	12-53-53	7560	ϕ = 23° S	LaPaz gives
3011	Cartuja	12-54-01	9060	λ = 65° W	ϕ = 23°·6 S
	Toledo	12-54-11	9010	O = 12-54-00	λ = 68° W
	LaPaz	12-54-01	840	Location approximate	
	Almeria	12-54-00	9100		La Plata gives
	Toronto	12-53-57	7320		ϕ = 27° S
	St. Louis	12-53-53	7120		λ = 68° W
	La Plata	12-54·2	1300		
	Cincinnati	12-53-58	6960		
	Sucre	12-54-01	570		
Dec. 1	Helwan	4-37-34	9800	ϕ = 2°·7 N	
3014	Pulkovo	4-37-34	9830	λ = 123° E	
	Zi-ka-wei	4-37-41	3140	O = 4-37-34	
	Kucino	4-37-30	9400		
	Tachkent	4-37-29	6800		
Dec. 11	Ekaterinburg	17-25-39	8500	ϕ = 4° S	
3017	Zi-ka-wei	17-24-42	4080	λ = 122° E	
	Tachkent	17-25-28	7380	O = 17-25-16	
				Location and O approximate.	
Dec. 28	Pulkovo	8-54-56	6430	ϕ = 54° N	Pulkovo gives
3023	St. Louis	8-55-09	7650	λ = 161° E	ϕ = 55°·1 N
	Makéevka	8-54-50	7460	O = 8-54-54	λ = 158°·1 E
	Baku	8-54-48	7720		
	Tachkent	8-54-50	6490		
	Kucino	8-54-53	6620		
Dec. 28	Algiers	18-20-15	9740	ϕ = 53° N	Ekaterinburg gives
3024	Almeria	18-20-22	9710	λ = 163° E	ϕ = 55° 7′ N
	Apia	18-20-39	8120	O = 18-20-20	λ = 163° 43′ E
	Barcelona	18-19-51	9850		
	Belgrade	18-20-23	8440		
	Berkeley	18-20-03	6240		
	Baku	18-20-09	7890		
	Cartuja	18-20-30	9600		

LOCATION OF EPICENTRES, 1927

Date	Station	O	Δ	Epicentre	Other Locations
	Cincinnati..........	18–20–25	7950		
	Denver..............	18–20–48	6900		
	Ekaterinburg........	18–20–09	5780		
	Firenze.............	18–20–12	9020		
	Graz................	18–20–21	8380		
	Hamburg.............	18–20–18	7850		
	Harvard.............	18–20–31	8200		
	Helwan..............	18–20–30	9400		
	Hohenheim...........	18–20–41	7950		
	Ithaca..............	18–20–37	7900		
	Jinsen..............	18–20–18	3140		
	Kobe................	18–20–02	3190		
	Lick................	18–20–09	6220		
	Manila..............	18–19–34	6480		
	Nagasaki............	18–20–22	3440		
	Ottawa..............	18–20–26	7720		
	Osaka...............	18–21–24	2690		
	Paris...............	18–20–24	8420		
	Pulkovo.............	18–20–12	6680		
	Ravensburg..........	18–20–04	8620		
	Richmond............	18–20–25	8190		
	Strasbourg..........	18–20–19	8380		
	St. Louis...........	18–20–34	7720		
	Sumoto..............	18–20–00	3270		
	Toronto.............	18–20–24	7800		
	Tachkent............	18–20–20	6470		
	Uccle...............	18–20–13	8300		
	Wien................	18–20–23	8150		
	Zi-ka-wei...........	18–20–07	4150		
	Zürich..............	18–20–24	8480		

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PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

R. MELDRUM STEWART, *Director*

Vol. VII

SEISMOLOGY

No. 6

Empirical Investigation of Surface-Waves Generated by Distant Earthquakes

BY

L. DON LEET

OTTAWA
F. A. ACLAND
PRINTER TO THE KING'S MOST EXCELLENT MAJESTY
1931

PREFACE

I wish to acknowledge a particular indebtedness to Mr. Ernest A. Hodgson, Chief of the Seismological Division of the Observatory, and to Mr. R. Meldrum Stewart, the Director, without whose interest, co-operation, and advice, the prosecution of the investigation here reported would have been impossible. I wish, further, to express my thanks to Dr. James B. Macelwane, S.J., whose papers on surface-waves, at Washington and New York in April, 1929, and subsequent specific suggestions, led to the selection of those waves as a subject for study; to Dr. Frank Wenner for his ready assistance in clearing up certain problems concerning instrumental registration theory; and to Dr. Beno Gutenberg for his valuable suggestions during a series of personal conferences made possible in the course of the investigation by his visit to Ottawa.

DOMINION OBSERVATORY, L. DON LEET.
OTTAWA, CANADA.

December 1, 1929.

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EMPIRICAL INVESTIGATION OF SURFACE-WAVES GENERATED BY DISTANT EARTHQUAKES

By L. Don Leet

The data for this investigation were taken, with five exceptions, from records of the Seismological Division of the Dominion Observatory, Ottawa, Canada. Four records supplementing these were obtained at the Harvard seismograph station, Cambridge, Massachusetts, U.S.A., and one at Rio de Janeiro, on Milne-Shaw seismographs adjusted to the same constants as the instruments of that make in service at Ottawa.

There were several important reasons for concentrating on Ottawa records. In the first place, it was felt that valuable information about surface-waves could be deduced from the records of a single station, obtained over a period of years. These offer for study earthquakes from all parts of the globe registered under identical conditions by the same instruments *with constants well determined*, as opposed to the material represented by the records of a single quake at many stations. It is of course recognized that an additional unknown is thus introduced, in the form of differing epicentral conditions. It is felt, however, that this is more than compensated by the elimination of uncertainties regarding timing and instrumental constants, which inevitably accompany the use of records from many stations.

Another consideration in practically limiting the study to Ottawa records is the time service. Timing uniform to within a few hundredths of a second on all the records used is a consequence of the station's direct connection with the Observatory's time service. It is difficult to over-emphasize the importance of this exact timing.

A further factor, which made it possible to widen the scope of the investigation by confining it to Ottawa records, is the system of filing and record-keeping which has been in use at Ottawa for some six years ([36]). This makes it possible to secure, in a couple of hours, certain types of information which could be obtained otherwise only by the examination of several thousand record sheets.

Earthquakes Studied

Records for the period between 1922 and 1929 were examined and 127 of the quakes best recorded selected for study. The locations of these are shown in fig. 5. Distances and azimuths from Ottawa are indicated. Numbers underlined are the Ottawa serial numbers of the quakes for which earth amplitude graphs were made.

Epicentre locations up to and including the year 1927 were determined at Ottawa ([13]) For the purpose of securing uniformity, this series of locations has been based on the Klotz Tables ([41]). The positions of the epicentres were determined by the stereographic projection method.

As the location work of the Observatory has been discontinued from the close of 1927, the epicentres for the few quakes used from 1928 and 1929 records were taken from the preliminary determinations of the United States Coast and Geodetic Survey and of the Central Station of the Jesuit Seismological Association at St. Louis.

Table I presents a reference list of the 127 quakes the records of which were used in obtaining the final results of the investigation. The Ottawa quake records have been given serial numbers since April 1, 1908. These numbers are used throughout this report to identify quakes under discussion.

TABLE I.—QUAKES WHOSE RECORDS WERE USED IN THIS INVESTIGATION

Ottawa Number	Date	O (GMT)	Distance in km.	Latitude	Longitude
		h. m. s.			
1274	1922, April 8	20-42-15	4,450	72·0 N.	8·5 W.
1351	1922, November 7	23-00-23	8,060	27·0 S.	73·0 W.
1353	1922, November 11	04-32-48	8,230	28·7 S.	72·0 W.
1354	1922, November 11	18-09-34	8,080	27·0 S.	71·0 W.
1356	1922, November 17	11-03-03	8,020	27·0 S.	77·3 W.
1386	1923, February 2	05-07-45	7,260	52·0 N.	164·0 E.
1387	1923, February 3	16-01-40	7,620	52·5 N.	162·0 E.
1417	1923, February 24	07-34-36	7,390	54·0 N.	166·7 E.
1446	1923, April 13	15-30-56	7,380	56·0 N.	163·0 E.
1462	1923, May 4	16-26-42	5,520	55·0 N.	156·5 W.
1531	1923, July 13	11-13-43	9,520	31·3 N.	131·0 E.
1536	1923, July 18	01-05-55	3,600	43·6 N.	29·5 W.
1537	1923, July 18	06-02-11	3,600	43·6 N.	29·5 W.
1571	1923, August 28	23-15-06	3,470	24·4 N.	106·0 W.
1573	1923, September 1	02-58-36	9,780	35·1 N.	140·2 E.
1639	1923, November 5	21-57-55	11,300	28·5 N.	132·5 E.
1663	1923, December 5	20-56-43	7,640	40·5 N.	24·8 E.
1682	1924, January 14	20-50-30	9,300	36·5 N.	139·2 E.
1706	1924, March 4	10-07-49	3,900	10·5 N.	84·0 W.
1707	1924, March 4	11-44-02	3,780	10·0 N.	84·5 W.
1715	1924, March 11	10-41-18	3,900	10·0 N.	84·0 W.
1747	1924, April 14	16-20-32	14,000	6·8 N.	122·5 E.
1753	1924, April 21	20-01-04	3,440	20·0 N.	100·0 W.
1763	1924, May 1	19-54-27	3,690	12·5 N.	88·0 W.
1805	1924, June 26	01-37-20	16,100	57·0 S.	159·0 E.
1812	1924, June 30	15-44-30	8,780	47·5 N.	149·0 E.
1815	1924, July 3	04-40-10	10,620	36·0 N.	86·0 E.
1856	1924, August 14	18-02-37	10,140	37·0 N.	141·5 E.
1866	1924, August 25	23-07-04	7,600	55·0 N.	164·0 E.
1870	1924, August 30	03-05-15	13,300	12·0 N.	125·5 E.
1885	1924, September 13	14-34-08	8,740	40·0 N.	43·0 E.
1887	1924, September 13	13-13-07	7,200	50·5 N.	177·5 E.
1910	1924, October 14	05-00-12	3,530	22·5 N.	44·5 W.
1917	1924, October 20	19-52-46	7,320	56·0 N.	166·0 E.
1957	1925, January 18	12-06-02	8,400	49·0 N.	154·0 E.
1961	1925, January 26	19-02·2	4,140	8·5 N.	79·5 W.
1963	1925, January 28	10-58·4	4,140	8·5 N.	79·5 W.
1969	1925, February 1	05-23-58	8,860	45·0 N.	150·0 E.
1974	1925, February 2	19-46-50	9,230	44·0 N.	149·0 E.
1996	1925, February 23	23-53-43	4,700	60·8 N.	146·7 W.
1999	1925, March 1	02-19-20	480	47·6 N.	70·1 W.
2028	1925, March 22	08-41-53	13,300	17·0 S.	168·0 E.
2039	1925, March 29	21-12-27	3,980	9·0 N.	79·5 W.
2045	1925, April 11	10-42-08	16,000	34·0 S.	59·0 E.
2125	1925, June 28	01-21-06	2,690	45·0 N.	110·8 W.
2131	1925, June 29	14-42-16	3,900	33·5 N.	118·5 W.
2149	1925, July 7	14-12-20	4,080	20·0 N.	107·0 W.
2151	1925, July 7	17-43-34	3,200	18·0 N.	61·5 W.

TABLE I.—QUAKES WHOSE RECORDS WERE USED IN THIS INVESTIGATION—*Continued*

Ottawa Number	Date	O (GMT)	Distance in km.	Latitude	Longitude
		h. m. s.			
2178	1925, August 7	07-47-50	3,600	19·5 N.	100·5 W.
2194	1925, August 19	12-07-31	7,390	55·0 N.	166·0 E.
2202	1925, August 29	22-36-35	3,560	25·0 N.	109·0 W.
2244	1925, October 5	04-09-07	3,540	14·0 N.	84·5 W.
2245	1925, October 5	04-11-08	3,050	18·0 N.	81·0 W.
2250	1925, October 13	17-40-31	4,900	10·5 N.	43·0 W.
2297	1925, December 10	14-14-40	3,680	14·0 N.	93·0 W.
2307	1925, December 19	16-09-32	9,400	31·7 S.	112·0 W.
2336	1926, January 25	00-36-14	13,200	10·0 S.	162·0 E.
2350	1926, February 8	15-17-38	3,900	12·0 N.	88·5 W.
2356	1926, February 15	02-59-50	3,700	13·0 N.	86·5 W.
2381	1926, March 17	11-53-37	3,530	12·0 N.	82·0 W.
2413	1926, April 12	08-32-20	13,050	10·0 S.	165·0 E.
2471	1926, June 26	19-46-31	7,900	35·5 N.	27·5 E.
2567	1926, August 30	11-38-05	7,480	37·0 N.	24·5 E.
2570	1926, September 2	01-21-55	16,100	33·0 S.	59·0 E.
2580	1926, September 10	10-34-23	16,000	9·0 S.	113·0 E.
2585	1926, September 16	17-59-15	13,600	10·0 S.	158·0 E.
2616	1926, October 13	06-02-21	7,020	51·5 N.	178·0 W.
2617	1926, October 13	14-17-47	6,920	51·0 N.	178·4 W.
2618	1926, October 13	19-08-08	6,780	50·4 N.	174·0 W.
2619	1926, October 14	02-11-09	6,800	51·0 N.	175·8 W.
2623	1926, October 22	12-35-20	4,160	37·0 N.	125·0 W.
2624	1926, October 22	13-35-15	4,160	37·0 N.	125·0 W.
2630	1926, October 26	03-44-43	14·000	1·0 S.	140·0 E.
2639	1926, October 30	19-41-53	3,700	49·0 N.	128·5 W.
2646	1926, November 5	07-55-39	3,520	14·2 N.	85·5 W.
2697	1927, January 24	01-05-6	13,600	17·0 S.	167·0 E.
2738	1927, March 7	09-27-41	10,230	35·5 N.	135·4 E.
2779	1927, April 14	06-23-35	8,320	31·0 S.	70·3 W.
2799	1927, May 9	20-05-36	4,020	14·0 N.	93·0 W.
2811	1927, May 22	22-32-40	10,800	37·0 N.	102·5 E.
2818	1927, June 3	07-12-02	15,200	8·0 S.	131·0 E.
2889	1927, August 5	21-13-02	9,750	38·6 N.	142·0 E.
2890	1927, August 6	00-14-00	5,500	54·8 N.	157·0 W.
2898	1927, August 10	01-35-30	4·200	7·0 N.	81·6 W.
2900	1927, August 10	11-36-11	14,600	2·0 S.	130·0 E.
2905	1927, August 18	19-27-50	10,000	36·0 N.	144·0 E.
2909	1927, August 20	23-54-28	4,370	6·3 N.	83·0 W.
2921	1927, September 3	19-47-40	4,880	10·7 N.	43·3 W.
2931	1927, September 11	22-15-42	7,950	44·5 N.	34·5 E.
2949	1927, October 2	04-47-45	3,530	12·0 N.	92·0 W.
2973	1927, October 24	15-59-50	4,260	57·0 N.	136·0 W.
2980	1927, November 4	13-51-00	3,910	34·4 N.	120·8 W.
2992	1927, November 14	00-12-04	7,020	70·0 N.	126·7 E.
3024	1927, December 28	18-20-20	7,720	53·0 N.	163·0 E.
3083	1928, March 16	05-01-01	13,400	23·0 S.	170·4 E.
3092	1928, March 22	04-16-57	3,590	14·0 N.	95·0 W.
3115	1928, April 17	03-25-16	3,380	16·0 N.	95·5 W.
3117	1928, April 18	19-22-50	7,620	42·3 N.	24·8 E.
3139	1928, May 14	22-14-33	5,680	8·0 S.	80·5 W.
3161	1928, May 27	09-50-33	9·580	39·0 N.	149·0 E.
3185	1928, June 17	03-19-20	3,700	14·0 N.	96·0 W.
3192	1928, June 21	16-26-52	4,650	61·8 N.	148·7 W.

TABLE I.—QUAKES WHOSE RECORDS WERE USED IN THIS INVESTIGATION—*Concluded*

Ottawa Number	Date	O (GMT)	Distance in km.	Latitude	Longitude
		h. m. s.			
3223	1928, August 4	18-26-01	4,000	14·0 N.	98·0 W.
3263	1928, October 9	03-01-02	3,700	15·0 N.	97·0 W.
3284	1928, October 25	12-32-57	3,720	12·0 N.	86·0 W.
3292	1928, November 1	04-12-43	3,250	26·0 N.	106·0 W.
3303	1928, November 20	20-35-09	7,550	23·0 S.	73·0 W.
3314	1928, December 1	04-06-06	8,980	35·0 S.	74·0 W.
3317	1928, December 2	04-20-26	8,920	35·0 S.	74·0 W.
3334	1928, December 19	11-37-ca	13,900	7·0 N.	128·0 E.
3341	1929, January 13	00-03-17	8,050	54·0 N.	154·0 E.
3343	1929, January 21	10-30-40	4,950	64·0 N.	152·0 W.
3344	1929, January 24	20-36-31	3,740	12·0 N.	90·0 W.
3352	1929, February 2	00-00-28	7,350	2·0 S.	23·0 W.
3361	1929, February 10	15-38-30	3,580	11·7 N.	90·8 W.
3368	1929, February 22	20-41-47	4,900	17·0 N.	35·3 W.
3370	1929, February 26	09-00-44	5,900	54·0 N.	163·0 W.
3372	1929, March 1	07-30-54	4,000	53·0 N.	132·0 W.
3381	1929, March 7	01-34-37	6,480	51·0 N.	170·0 W.
3395	1929, March 21	02-36-56	3,660	12·0 N.	90·0 W.
3437	1929, May 1	15-37-37	9,620	37·0 N.	58·0 E.
		(Harvard)	9,620		
3540	1929, July 5	14-19-00	7,000	50·0 N.	177·0 W.
		(Harvard)	7,500		
3542	1929, July 5	22-36-13	6,950	50·0 N.	177·0 W.
		(Harvard)	7,450		
3543	1929, July 6	02-03-46	6,950	50·0 N.	177·0 W.
		(Harvard)	7,450		
3544	1929, July 6	09-46-04	4,300	15·6 N.	43·4 W.
		(Harvard)	3,900		
3551	1929, July 7	21-23-07	6,980	50·0 N.	177·0 W.
		(Harvard)	7,450		
3654	1929, September 17	19-17-27	3,930	52·0 N.	133·0 W.

INSTRUMENTS

During the period covered by this investigation, there were in service at Ottawa one vertical component and four horizontal component seismographs: a Spindler-Höyer vertical, following the design of Wiechert; Milne-Shaw seismographs 17 and 23; two Bosch photographic instruments.

All constants of the instruments had been determined at regular intervals. This is of the greatest importance because of the direct and fundamental influence of the constants of an instrument on the character of the records which it yields. The manufacturers of the better modern instruments, such as the Milne-Shaw, Wilip-Galitzin, Wenner, and others, are increasing the recording value of stations tremendously by making it advisable for all the instruments of a given kind to be adjusted to the same constants and making it an easy matter to check those constants frequently.

Table II records the constants of the Ottawa and Harvard stations, and of the instruments as determined at intervals throughout the period for which records were studied.

TABLE II.—STATION AND INSTRUMENTAL CONSTANTS

OTTAWA SEISMOLOGIC STATION—DOMINION OBSERVATORY

Latitude = 45° 23′ 38″ North
Longitude = 75° 42′ 57″ West
Elevation = 83 meters

Foundation: Boulder clay over Ordovician limestone
Time: Mean Greenwich, midnight to midnight
Time correction: Within ·25 sec.

INSTRUMENTS—FIXED CONSTANTS

Instrument	Symbol	Registration	Damping	Paper Speed	Mass
Bosch	I	Photographic	Air	15 mm/minute	200 grams
Bosch	II	Photographic	Magnetic	15 mm/minute	200 grams
Milne-Shaw	17	Photographic	Magnetic	8 mm/minute	1 pound
Milne-Shaw	23	Photographic	Magnetic	8 mm/minute	1 pound
Spindler-Hoyer	W	Smoked Sheet	Air	15 mm/minute	80 kg.

INSTRUMENTS—DETERMINED CONSTANTS

Instrument	T_o	r	R	V	Damping ratio	Com-ponent	Deflection per second of arc tilt	Date determined
	sec.	cm.	dynes				mm.	
W	6·0	0·06	0·27	160	5 : 1	Z		1922, July 26.
I	5·5			120	2 : 1	NS		1922, December.
II	6·5			120	20 : 1	EW		1922, December.
17	12·0			250	20 : 1	EW	44·0	1922, December.
23	12·0			250	20 : 1	NS	44·0	1922, December.

These are normal operating constants. They were effective except as noted below, where only those which were changed are listed.

II	7·8				18 : 1			1923, February 7.

During March and April, 1923, No. 23 was run to record the EW component, with various values for the damping ratio (35). It was kept at:—20 : 1 until 1923, March 9
15 : 1 until 1923, March 17
10 : 1 until 1923, May 3
5 : 1 until 1923, May 30

II	5·8							1923, April 4.
II	5·3							1923, May 3.
17							44·5	1923, May 3.
23					5 : 1	EW	42·0	1923, May 3
W	5·9	0·06						1923, May 30.
23	Out of operation from 1923, July 20, to 1924, January 9, at Ottawa, the instrument being used for experimental purposes at Shirley Bay and Kemptville, Ont.							

TABLE II—STATION AND INSTRUMENTAL CONSTANTS—*Continued*

OTTAWA SEISMOLOGIC STATION—DOMINION OBSERVATORY—*Concluded*

INSTRUMENTS—DETERMINED CONSTANTS—*Concluded*

Instrument	T_0	r	R	V	Damping ratio	Component	Deflection per second of arc tilt	Date determined
	sec.	cm.	dynes				mm.	
W	5·5				4 : 1			1923, August 22.
II	5·4				15 : 1			1923, August 21.
23	12·0				20 : 1	NS	44·0	1924, January 9.
I	5·5				9 : 5			1924, March 5.
II	5·8				13 : 4			1924, March 5.
I	5·3				2 : 1			1924, May 7.
II	6·0				15 : 1			1924, May 7.
17							51·0	1924, May 7.
23							44·6	1924, May 5.
17							44·0	1924, November 28.
23							44·0	1924, November 28.
II	5·5				10 : 1			1926, February 16.
17							43·0	1926, February 12.
23							42·0	1926, February 12.
W	5·2							1926, February 15.
I	5·2							1927, January 31.
II	5·9							1927, January 31.
W	5·1							1927, January 31.
17							42·5	1927, February 8.
23							43·0	1927, February 13.
II	6·2							1928, January 10.
17							44·0	1927, December 30.
23							44·0	1928, January 11.
W	5·2							1928, January 18.
II	6·9				14 : 1			1929, February 2.
23							43·0	1929, January 31.
W	5·0				6 : 1			1929, February 25.
W	Out of operation from June 15 to July 4, while it was being moved to a recording pier in a constant temperature vault.							
W	7·0	0·053	0·13		11 : 1			1929, July 5.

TABLE II—STATION AND INSTRUMENTAL CONSTANTS—*Concluded*

HARVARD UNIVERSITY
SEISMOGRAPH STATION, DEPARTMENT OF GEOLOGY AND GEOGRAPHY,
CAMBRIDGE, MASSACHUSETTS, U.S.A.

Latitude =42° 22′ 36″ North
Longitude =71° 06′ 59′ West
Elevation =5·367 meters

Foundation: Glacial sand over clay
Time: Mean Greenwich, midnight to midnight
Time correction: Within 0·5 second.

INSTRUMENTS—FIXED CONSTANTS

Instrument	Symbol	Registration	Damping	Paper Speed	Mass
Milne-Shaw....................	43	Photographic	Magnetic	8 mm/minute	1 pound
Milne-Shaw....................	44	Photographic	Magnetic	8 mm/minute	1 pound

INSTRUMENTS—DETERMINED CONSTANTS

Instrument	T_o	V	Damping ratio	Component	Deflection per second of arc tilt	Date determined
	sec.				mm.	
43....................	12·0	250	20 : 1	EW	44·0	1928, November 28.
44....................	12·0	250	20 : 1	NS	44·0	1928, November 28.

Particular attention should be paid to the constants of the mechanically recording vertical seismograph. A. Mohorovičić [61], Reid [74], and others have stressed the importance of accurate determinations of constants, and indicated procedures to follow. Mohorovičić, in particular, commented on the fatal carelessness of most seismograph stations in such matters.

It is essential to determine the sensitivity of a seismograph with the damping removed. Optically registering instruments have, in general, an exceptionally small friction. It is also far less variable than that of mechanically recording instruments. This problem, therefore, concerns the vertical much more vitally than any of the other instruments at Ottawa.

The friction, R, in dynes is given by Mohorovičić as

$$\mathrm{R} = \frac{r\,4\pi^2\,M}{T_o^2\,V^2} \quad \dots\dots (1)$$

where r is the half width in centimeters of the zone within which friction will completely arrest the recording pen; T_o the undamped period of the seismograph in seconds; M the mass of the pendulum in grams; and V the static magnification, that is, the ratio of the amplitude of the writing point to the corresponding amplitude of the displacement of the centre of gravity of the mass.

According to Mohorovičić, the best instruments, properly handled, should have a friction of less than one-half of a dyne. One of the most critical places at which friction must be as low as possible if this value is to be obtained, is the contact of the writing point with the smoked sheet. It should press so lightly upon the paper that the slightest reduction of the pressure would prevent its recording. The line written in the soot should become virtually a series of dots. An effective means of accomplishing this was first proposed by Marvin in 1906 ([55]) and further mentioned by Reid ([71]) and Hodgson ([34]). It consists of a small electric buzzer attached rigidly to the small post supporting the stylus bearings. The writing arm is, of course, carefully counterbalanced also.

The vertical seismograph at Ottawa, equipped with a sensitizing buzzer, and kept under rigorous temperature control ([34]), was brought to a high degree of operating efficiency. In July, 1922, R was found to be ·27 dynes. In July, 1929, after the instrument's removal to a different recording position, a period of 7 seconds, instead of the 6 seconds used for some time, was found to be practicable. With that set-up, from a decay curve whose maximum amplitude was 4·5 cm., R was found to be only ·13 dynes, a remarkably low value for such an instrument, r in this case being ·053 cm.

These facts are stressed because of the important rôle of the vertical seismograph in certain phases of the investigation. The nature of earth movements during the passage of the Rayleigh-wave has been carefully studied, and here the ratio of vertical to horizontal components of true earth amplitudes is important. Where investigators have found vertical components less than horizontal, rather than of the order of 1·5 times as great, there has been a tendency to discount the reliability of the vertical record. Accordingly, every effort has been made in the present study to base findings only on the records of instruments which were known to be in optimum adjustment.

Earth Amplitude Graphs of Surface-waves—Theory

A thorough analysis of the surface-waves from distant earthquakes can be made only in terms of the actual movement of the earth particle. If that is determined, an understanding of the nature of the waves themselves is possible on the principle that any undulatory process may be described by considering a given point in the path of the wave as executing a vibration.

As a preliminary to certain parts of the present investigation, portions of the surface-wave groups of several earthquakes were reduced to actual earth amplitudes and plotted on a uniform time scale. The accuracy of such work must be examined on three main counts: (1) the exactness with which trace amplitudes can be translated into true amplitudes, (2) the relationship in phase between the earth particle and the record trace, and (3) the reliability of trace amplitudes where there are sudden changes of earth amplitude or period.

A. Mohorovičić ([61]) gives as his finding after detailed examination that the mean error in the determination of true earth movements amounts to about ten per cent. This is under the assumption that all measurements of instrumental constants are made with the greatest of care. If they are only moderately well determined, the error may become as much as double that amount.

With regard to phase relationships, in general a properly damped pendulum leads in phase a sustained harmonic motion of longer period that is impressed upon it. The amount depends on the ratio between the period of the forced motion and that of the undamped pendulum as well as upon the amount of damping. Thus, pendulums of different periods will lead the same earth vibration in phase by different amounts. At the same time, any given pendulum's phase angle changes as the earth period changes.

The first of these effects can be taken into account readily by the application of a correction to the phase of one pendulum to render it comparable to that of another of different period, when both are recording the same earth vibration.

The second, however, leads to disastrous complications in all but certain special cases. The horizontal seismographs of most recording stations are oriented in NS and EW planes. Accordingly, if waves arrive whose planes of propagation do not intersect the surface at the station in either of these pairs of cardinal directions, the resulting motion will in general have a component on each instrument. At such times as mixed waves are arriving (some with dominantly transverse, others with longitudinal, horizontal vibrations, and each type with a different period), a resolution of the resulting records in terms of absolute earth amplitudes, and of phases of each wave type becomes a problem difficult, if not impossible, to solve.

As an example of the simultaneous arrival of transverse surface-waves and Rayleigh-waves with their longitudinal and vertical displacements, each with a different period, let us examine the records from an epicentre directly south of Ottawa. Such records show the component movements resolved on the appropriate seismograms (fig. 18c). Between 5h 12 m and 5h 14 m there is a distinct vibration of the EW component with an apparent period of 26 seconds. At the same time the NS and vertical display a 30-second vibration period. Figs. 18a and 18b show the same thing in the graphs of computed true earth amplitudes.

Reid ([71]), following Wiechert, has shown the difference of phase for varying ratios of earth period to instrument period. His diagram assumes a phase difference of about 180° for periods of ground movement very short relative to the instrument's period. Wenner ([126]) treats the same problem on the assumption of zero phase difference for short earth periods. Whether a momentary displacement of the ground and the resulting displacement shown on the record are considered to have the same or opposite sign is a matter of convention. The choice of assumptions does not affect the computation of phase difference between two instruments of different periods as they record the same earth vibration.

Fig. 8 of Wenner's valuable paper ([126]) is plotted from the equation:—

$$\tan \alpha = \frac{\omega D}{\omega^2 K - U} \text{ ([127])} \qquad (2)$$

where α is the phase angle; ω is the frequency of earth displacement, or 2π divided by the period; D is the damping constant of the seismograph; K the moment of inertia of the moving system of the seismograph; and U the restoring constant of the seismograph D is taken equal to $2\sqrt{KU}$, the condition giving critical damping; K is taken equal to

$4U$, giving a period of 4π or $12 \cdot 6$ seconds for the seismograph; and, as indicated above, the phase displacement is assumed to be zero when ω is very large, that is, when the period of the ground movement is very short.

These constants appear in the equation of motion of the steady mass of a seismograph with respect to its support,

$$K\frac{d^2\varphi}{dt^2} + D\frac{d\varphi}{dt} + U\varphi = LM\frac{d^2X}{dt^2} \qquad (3)$$

where φ is the angular displacement; t is the time; X is the displacement of the support; L is the distance from the centre of mass of the moving system of the seismograph to the axis of rotation; and M is the mass of the moving system of the seismograph.

In the present investigation, we shall not be concerned with the absolute amount by which our instruments lead the ground movement. We need to know, rather, the difference between the phase lead of a 12-second pendulum and that of a 6-second, since the Milne-Shaw seismographs have the former period and the vertical has the latter. Where Bosch and vertical records are compared, the problem does not exist, for the Bosch period is practically the same as that of the vertical. Differences in damping ratios also affect phase, theoretically. The magnitude of this effect in the present study, however, was within the limits of observational error.

The periods of earth displacements whose records on 6- and 12-second instruments were compared were all over 20 seconds, within a range where available graphs indicate expectable phase differences of about 3 seconds and less. As the earth period increases, the phase difference between the instruments decreases.

Accordingly, wherever the Milne-Shaw records were compared with the vertical, determinations of phase differences were made. The equipment at Ottawa fortunately made it possible to do this instrumentally, since 6-second Bosch and 12-second Milne-Shaw records of the same horizontal components of given quakes were available for comparison. This is illustrated by fig. 11a, where earth amplitudes computed from Bosch II, EW, are plotted on the same time scale as those computed from Milne-Shaw 17, EW. The short-period Bosch registers the maxima consistently earlier than the longer-period Milne-Shaw, as theory indicates it should. It is immaterial whether the Bosch be regarded as leading the earth displacement by more than the Milne-Shaw, or lagging behind it less.

Berlage (5) investigated the behaviour of the Milne-Shaw seismograph at the onset of impulses. This should indicate, qualitatively at least, its reaction to marked changes of amplitude as well. His results suggest that the instrument does not respond accurately to such changes, in its representation of apparent period or in amplitudes computed from its trace.

Unfortunately, any significance that these results might have had so far as Milne-Shaw recording is concerned, seems to have been vitiated by the use of a 5 : 1 damping ratio. Computations and experiments were made "dans le cas où le rapport d'amortissement est le rapport habituel, 5 : 1." Instructions (95) for the operation of these instruments, however, state quite clearly that 20 : 1 is the ratio to be used.

The effect which the damping ratio would have on Milne-Shaw registration was well demonstrated by a series of experiments conducted by Hodgson at Ottawa ([35]). Two instruments were operated to record the same component of motion, with all constants the same; then the damping ratio of one was reduced successively to 15 : 1, 10 : 1, and 5 : 1. There were no measurable differences in the seismograms for damping ratios of 10 : 1 and greater. There were distinct differences, however, between 5 : 1 and 20 : 1 recording. Fig. 1 shows records of quake No. 1462 obtained during the course of these experiments. In particular, the impulse at the left of the figure is similar to the type used by Berlage. The record of the instrument with 5 : 1 damping differs from that of the one with 20 : 1 by an amount which seems to be comparable to the discrepancies reported by Berlage between theory and observation, both in apparent period and in amplitude.

So far as can be found, there has been no determination made as yet of the effect of sudden amplitude changes on the recording of, say, a Milne-Shaw seismograph in the surface phase. If the negative evidence adduced by comparing the Berlage and Hodgson experiments is accepted as an indication, a properly damped Milne-Shaw seismograph gives a record of such changes which is accurate within the present limits of measurement.

The reaction of the Milne-Shaw to sudden changes of period, when the amplitude of motion is constant, was investigated by Rothé ([82]). He found that the inscription immediately indicated a variation of magnification proportional to the variation of period, as indicated in the Milne-Shaw magnification curve ([95]).

Earth Amplitude Graphs of Surface-waves—Procedure

Earth amplitudes were computed from Milne-Shaw seismograms by using the magnification curve supplied with these instruments ([95]). This is based on the Wiechert formula given below.

Bosch and vertical trace amplitudes were reduced by the aid of curves drawn from Wiechert's formula ([128]):—

$$V_d = \frac{V}{\sqrt{\left[1 - (T_e/T_o)^2\right]^2 + 4\left(\frac{T_o}{2\pi\tau}\right)^2 (T_e/T_o)^2}} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (4)$$

where V_d is the dynamic magnification, V is the static magnification, T_e and T_o, respectively, the periods of the earth particle and of the undamped pendulum, and τ the relaxation time. V is constant; V_d is not. These curves can be found in the Klotz Tables ([41]).

Tables III, IV, and V were constructed as computation aids.

The first step was to establish the zero line through the portion of the seismogram to be measured. Then the exact time to the nearest second of each turning point in the trace was measured, with the trace amplitude, or distance from the zero line, of the point. The effective period, which determines V_d, was assumed to be the time between successive turning points on the same side of the zero line. Then, with the effective earth period and the trace amplitude at a given point known, the computed true earth amplitude was read directly from the tables indicated.

A sample computation form indicates the method of tabulating these data:—

Quake 3544 MS 23 NS Up trace = South movement of ground 1929, Aug. 13.

Time	T_o	Trace Amp in ½ mm.	Microns per ½ mm.	Microns
10-05-21	(26)	3 N	12	36
13				
34	29	4 S	12	48
16				
50	30	3 N	12	36
14				
06-04	24	5 S	8	40
10				
14	24	4 N	8	32
14				
28	27	5 S	10	50
13				
41	21	4 N	6	24
8				
49	16	7 S	4	28
8				
57	19	5 N	5	25
11				
07-08	22	5 S	7	35

The graphs for this quake are shown in fig. 6.

Earth amplitudes were computed only for the turning points. Intermediate positions were obtained by graphical interpolation.

Measurements of trace amplitudes were made to the nearest ⅛ mm. Accordingly, the limits of accuracy at each point are represented by a fourth of the figure in the column headed "microns per ½ mm." making no allowance for the limits within which the period was determined—approximately ± 1 second.

Earth amplitude graphs were made for 56 components, representing 18 quakes. Each begins at the earliest surface phase which can be identified. They vary in length from 15 to 25 minutes. They are reproduced in figs. 6 to 23. The accuracy of these graphs, it must be kept in mind, is subject to the conditions discussed on page 274.

TABLE III.—SECONDS PER HALF MILLIMETER

For normal minute interval of 15 mm.

(Bosch and Vertical)

½ mm.	Minute Interval in ½ mm.							
	25	26	27	28	29	30	31	32
1	2·4	2·31	2·22	2·14	2·07	2	1·94	1·88
2	4·8	4·62	4·44	4·29	4·14	4	3·87	3·75
3	7·2	6·92	6·67	6·43	6·21	6	5·81	5·63
4	9·6	9·23	8·89	8·57	8·28	8	7·74	7·50
5	12·0	11·54	11·11	10·71	10·35	10	9·68	9·38
6	14·4	13·85	13·33	12·86	12·41	12	11·61	11·25
7	16·8	16·15	15·56	15·00	14·48	14	13·55	13·23
8	19·2	18·46	17·78	17·14	16·55	16	15·48	15·00
9	21·6	20·77	20·00	19·29	18·62	18	17·42	16·88
10	24·0	23·08	22·22	21·43	20·69	20	19·36	18·75
11	26·4	25·39	24·44	23·57	22·76	22	21·29	20·63
12	28·8	27·69	26·67	25·71	24·83	24	23·23	22·50
13	31·2	30·00	28·89	27·86	26·90	26	25·16	24·38
14	33·6	32·31	31·11	30·00	28·97	28	27·09	26·25
15	36·0	34·62	33·33	32·14	31·04	30	29·03	28·12
16	38·4	36·92	35·56	34·29	33·10	32	30·97	30·00
17	40·8	39·23	37·78	36·43	35·17	34	32·90	31·88
18	43·2	41·54	40·00	38·57	37·24	36	34·84	33·75
19	45·6	43·85	42·22	40·71	39·31	38	26·77	35·63
20	48·0	46·15	44·44	42·86	41·38	40	38·71	37·50
21	50·4	48·46	46·67	45·00	43·45	42	40·65	39·38
22	52·8	50·77	48·89	47·14	45·52	44	42·58	41·25
23	55·2	53·08	51·11	49·29	47·59	46	44·52	43·13
24	57·6	55·39	53·33	51·43	49·66	48	46·45	45·00
25	60·0	57·69	55·56	53·57	51·73	50	48·39	46·88
26		60·00	57·78	55·71	53·79	52	50·32	48·75
27			60·00	57·86	55·86	54	52·26	50·63
28				60·00	57·93	56	54·19	52·50
29					60·00	58	56·13	54·38
30						60	58·07	56·25
31							60·00	58·13
32								60·00

TABLE IV.—SECONDS PER HALF MILLIMETER

For normal minute interval of 8 mm.

(Milne-Shaw)

½ mm.	Minute Interval in ½ mm.					
	14·5	15	15·5	16	16·5	17
0·5	2·07	2	1·94	1·88	1·82	1·77
1·0	4·14	4	3·87	3·75	3·64	3·53
1·5	6·21	6	5·81	5·63	5·45	5·29
2·0	8·28	8	7·74	7·50	7·27	7·06
2·5	10·35	10	9·68	9·38	9·09	8·82
3·0	12·41	12	11·61	11·25	10·91	10·59
3·5	14·48	14	13·55	13·13	12·73	12·36
4·0	16·55	16	15·48	15·00	14·54	14·12
4·5	18·62	18	17·42	16·88	16·36	15·89
5·0	20·69	20	19·36	18·75	18·18	17·65
5·5	22·76	22	21·29	20·63	20·00	19·41
6·0	24·83	24	23·23	22·50	21·82	21·18
6·5	26·90	26	25·16	24·38	23·64	22·94
7·0	28·97	28	27·09	26·25	25·45	24·71
7·5	31·03	30	29·03	28·12	27·27	26·48
8·0	33·09	32	30·97	30·00	29·09	28·24
8·5	35·16	34	32·90	31·88	30·91	30·00
9·0	37·23	36	34·84	33·75	32·73	31·77
9·5	39·30	38	36·77	35·62	34·54	33·53
10·0	41·37	40	38·71	37·50	36·36	35·29
10·5	43·44	42	40·65	39·38	38·18	37·06
11·0	45·51	44	42·58	41·25	40·00	38·82
11·5	47·58	46	44·52	43·12	41·82	40·59
12·0	49·65	48	46·45	45·00	43·64	42·36
12·5	51·72	50	48·39	46·88	45·45	44·12
13·0	53·78	52	50·32	48·75	47·27	45·89
13·5	55·85	54	52·26	50·62	49·09	47·65
14·0	57·92	56	54·19	52·50	50·91	49·41
14·5	60·00	58	56·13	54·38	52·73	51·18
15·0		60	58·07	56·25	54·54	52·94
15·5			60·00	58·12	56·36	54·71
16·0				60·00	58·18	56·48
16·5					60·00	58·24
17·0						60·00

TABLE V.—MAGNIFICATION AND EARTH DISPLACEMENT

For Milne-Shaw Seismograph of 12s Period, Static Magnification 250, Damping Ratio 20 : 1

$$\frac{\text{Trace Amplitude in mm.}}{F} \times 1000 = \text{Earth Displacement in microns.}$$

$$\frac{\text{Trace Amplitude in } \tfrac{1}{2} \text{ mm.}}{2F} \times 1000 = \text{Earth Displacement in microns where } F \text{ is the Magnification Factor.}$$

T_e	F	$2F$	Microns per ½ mm. trace
4	250·0	500	2·00
5	248·0	496	2·02
6	245·0	490	2·04
7	240·0	480	2·08
8	232·5	465	2·15
9	222·0	444	2·25
10	210·0	420	2·38
11	196·0	392	2·55
12	182·0	364	2·75
13	167·5	335	2·99
14	152·5	305	3·28
15	140·0	280	3·57
16	126·0	252	3·97
17	115·0	230	4·35
18	105·0	210	4·76
19	95·0	190	5·26
20	87·0	174	5·75
21	79·0	158	6·33
22	73·0	146	6·85
23	67·0	134	7·46
24	61·5	123	8·13
25	57·5	115	8·77
26	53·0	106	9·43
27	49·0	98	10·20
28	46·0	92	10·87
29	43·0	86	11·63
30	40·5	81	12·35
31	38·0	76	13·16
32	35·5	71	14·08
33	33·0	66	15·15
34	31·0	62	16·13
35	29·0	58	17·24
36	27·5	55	18·18
37	26·0	52	19·23
38	24·5	49	20·41
39	23·5	47	21·28
40	22·5	45	22·22
Greater than 40	20·0	40	25·00

The measurement of time on the vertical records required special attention. The writing arm has a short radius—approximately 15·3 cm.—and introduces a decided curvature into the trace for amplitudes of more than a few millimeters. When this occurs, the exact time of a turning point cannot be determined by the foot of a perpendicular to the zero line. It is represented, rather, by the point on the zero line intersected by the arc of writing passing through the turning point. Accordingly, a transparent template was designed with an arc of 15·3 cm. radius and a zero line for reference inscribed on it. When the template's reference line coincides with the seismogram's zero line and its arc passes through a turning point, the time of the turning point is read at the point where the template's arc crosses the zero line.

The greatest inaccuracies in the earth amplitude graphs are to be expected in the early portions of the first surface-waves—normally the transverse type. The long periods of these waves are subject to a minimum magnification by the instruments. Furthermore, they are commonly combined with shorter period body waves. The reduction of the resulting trace is irregular and to a certain extent indefinite. The underlying long periods can be identified with reasonable accuracy, but the trace amplitude due to the long periods as distinguished from that introduced by the short must be estimated. These uncertainties, however, are present usually in only the first few minutes of the surface-wave group of a seismogram.

The quakes for which earth amplitude graphs were made, arranged by distance from Ottawa, are:—

Figure	Number	Distance in km.	Azimuth
6	3544	4,300	SE
4 and 7	1996	4,700	NW
8	3542	6,950	NW
9	3543	6,950	NW
10	3551	6,980	NW
11	3540	7,000	NW
12	3352	7,350	SE
13	2194	7,390	NW
14	3303	7,550	S
15	3117	7,620	NE
16	1387	7,620	NW
17	3024	7,720	NW
18	1353	8,230	S
19	3314	8,980	S
20	3161	9,580	NW
21	3437	9,620	NE
22	1815	10,620	N
23	2028	13,500	W

Earth Particle Path in the Rayleigh-wave

It has been known for some time that there are at least two distinct types of surface-waves, the transverse with no vertical component, and one whose vibrations are essentially longitudinal and vertical. The terms transverse and longitudinal are, of course, used with reference to the direction of propagation, or, more exactly, to the plane determined by the epicentre, recording station, and earth's centre.

The longitudinal-vertical waves have been most commonly referred to as "*M*," or maximum waves, owing to the fact that the maximum trace amplitude usually occurs during their passage, and as Rayleigh-waves, following Lord Rayleigh's theoretical results presented in 1885 ([69]), when he investigated waves propagated along the surface of a semi-infinite isotropic elastic solid, and described a wave type which is composed of longitudinal and vertical elements.

Though these waves often cause the maximum trace amplitude on a seismogram, the transverse surface waves frequently have the maximum true earth amplitude. Differential magnification of the long-period transverse and the shorter-period longitudinal-vertical waves by recording instruments accounts for the misleading appearance of the seismogram.

Throughout this report, reference will be made to the longitudinal-vertical surface waves as *R*-waves, or Rayleigh-waves, following the usage of Gutenberg ([29]). The transverse surface waves, again following Gutenberg, will be designated as Q-waves, or "querwellen" rather than Love-waves, as is often done. Their classification as Love-waves carries a genetic implication which at present seems to be unwarranted, since the theory of Love requires a layering of the outer crust, while transverse surface-waves have been shown by E. Meissner ([60]) to be possible where the velocity of bodily transverse waves increases with depth.

No satisfactory evidence has been found, in the present investigation, of the existence of other types at a recording station distant from the epicentre, though specific search was made for induced surface-wave forms described by Uller.

It is proposed at this point to investigate the path of the earth particle during the passage of Rayleigh-waves.

The first problem is the identification of the *R*-waves. The vertical component is, of course, the main criterion, since it distinguishes *R* from *Q*. The ideal situation is encountered in the recording of a quake which originated in an azimuth from the station which corresponds to the orientation of one of its horizontal instruments, an "end-on" quake, so to speak. In such a case, one horizontal component instrument records only *Q*, while the other horizontal and the vertical record *R* simultaneously.

Such a situation arose at the Ottawa station in the recording of the violent Atacama quake of 1922, November 11. This was number 1353, practically due south of Ottawa, at a distance of 8,230 km. Copies of tracings from the original seismograms are reproduced in fig. 18c. Earth amplitude graphs for this quake are shown in figs. 18a and 18b, in the first of which the vertical and NS are combined to show the recording of the *R*-waves.

The horizontal components of this quake were computed from Bosch records. No phase difference need be considered when comparing the NS with the vertical.

The nature of the earth particle movement can be readily ascertained. Starting at any given instant of time during the recording of the *R*-waves, the sequence of positions will be seen to be Up-South-Down-North, etc. In other words, *the rotation was retrograde with regard to the direction of propagation of the disturbance.*

A series of graphs of the earth particle path as shown by these records from 5h 10m 35s to 5h 20m 10s appears in fig. 24.

The path is elliptical. At the beginning of the first train of R-waves, the ellipse is oriented with its major axis horizontal. During the passage of the train, this orientation gradually changes, until at one point just after 13 minutes the major axis is vertical. In the more regular second train of R, the rotation ellipse is in a practically constant orientation, with the major axis horizontal and roughly in a ratio of 4 : 3 with the vertical minor axis. The reality of the apparent change in orientation of the ellipse in the first train may be open to question. As can be seen on the reproductions of the original seismograms in fig. 18c, the irregularities make it quite possible that errors in the determination of apparent turning points were sufficient to seem to alter the ellipse's orientation. In general, the rotation ellipses were found to have their major axes practically horizontal, or only slightly inclined.

The vertical seismograph during the recording of 1,353 was working with optimum sensitivity, and there seems to be no valid reason for doubting the reliability of the earth amplitudes computed from it. Any doubt which may be justifiable as to the reliability of the amplitude graphs would be connected rather with the Bosch instruments, and any corrections, if made, would be such as to increase the excess of horizontal over vertical motion. At another point of the investigation, several direct comparisons were made between earth amplitudes for the same quake computed from Bosch and Milne-Shaw records. The Bosch reductions were consistently smaller than the Milne-Shaw. Fig. 11a shows an interval from the surface phases of 3540 in which the EW component of true earth movement, as computed from Bosch II, is compared with the same as computed from Milne-Shaw 17.

Fig. 25 is an earth particle path graph for quake No. 2028, from 13,300 km. practically due west of Ottawa. It will be noted that here the sense of rotation is also retrograde as regards the propagation direction of the disturbance. The ellipse is flatter, the ratio of horizontal to vertical being nearer 3 : 1.

Like determinations were made for quakes 1274, 1815, 1910, 1961, 2045, 2307, 2336, 2413, 3117, and 3544, a total of twelve, including 1353 and 2028 above. These represent every cardinal azimuth from Ottawa, and three intermediate ones, where the combined horizontal components indicated a practically pure longitudinal vibration which could be combined with the vertical. Of the twelve, one originated in the vicinity of Jan Mayen, two in the southern mid-Atlantic, one on the isthmus of Panama, one southeast of Madagascar, one north of Easter island, one in Turkey, one in the interior of China, three in the south Pacific near the New Hebrides, and one in Chili. Without exception, the particle was found to be rotating in a retrograde sense as regards the propagation direction of the disturbance.

It remained, however, for quake 2413 to give the outstanding illustration of the phenomenon. It originated at a distance of 13,500 km. practically due west of Ottawa. The direct R-waves exhibit the retrograde rotation of the earth particle as usual. A little over an hour after the first R arrivals, the W_2-waves, which travelled from the origin via the antipodes and the major arc, reaching the station from the east, are among the most clearly marked of any that have been identified on Ottawa records. Where the first R-waves, coming from the *west*, exhibit a vibration direction of ***east-up-west-down***, that is, retrograde the W_2-waves, coming from the *east*, quite distinctly show a vibration sequence of ***west-up-east-down***.

Photographic facsimiles of the original records of the EW Bosch and the vertical component in the R and W_2 portions of 2413 are shown in fig. 2. Examine the top of the two lines of surface waves at, say, 46 minutes. On the exact minute, the horizontal component shows the earth particle at its maximum excursion to the east. The vertical component at that instant is approaching its maximum excursion up, which it reaches shortly after the minute. (The minute breaks are 2 seconds in length, from 58 to 60 seconds.) The sequence, then, is *east-up-west-down.* Now examine the 46th minute in the next line. (The arrival of W_2 is not shown in the figure.) Just before the minute, the horizontal component registers a maximum displacement to the west, followed on the minute by a maximum up on the vertical. The sequence here is *west-up-east-down.*

Earth Particle Path in the R-wave—Discussion and Theory

Only one reference, and that implicit, has been found in the literature on this subject, which touches on the fact that the earth particle traverses its elliptical path in a retrograde sense during the passage of R-waves. Mlle. Y. Dammann ([12]), in fig. 3 of her treatise on long-waves, reproduces records obtained at Strasbourg of the earthquake of 1924, March 4 (Ottawa No. 1706). The azimuth from Strasbourg was practically due west, so the EW and vertical components inscribed the R-waves. These two components are found to be directly comparable in amplitude and apparent period, but slightly out of phase, with the horizontal component in the lead. This gives a rotation sense of *east-up-west-down,* the retrograde motion established in the present investigation. Mlle. Dammann states, in discussing the records, "Le sens de parcours de l'ellipse est conforme à celui que prevoit la théorie de Lord Rayleigh."

There are not sufficient instrumental data given to show whether an apparent slight excess of vertical over horizontal trace amplitudes would be maintained, or increased, when the motion is reduced to true earth amplitudes.

In Lord Rayleigh's classic paper ([69]), page 447, equations ([39]), he gives as the equations determining motion at the surface, when $\sigma = \cdot 25$,

$$\alpha = \cdot 4227 \sin (pt + fx)$$
$$\gamma = -\cdot 6204 \cos (pt + fx) \qquad (5)$$

where α denotes displacement along the x-axis, and γ along the z-axis; p/f being the velocity of propagation of the progressive wave.

The motion of an earth particle, as defined by these equations, is determined by considering t to increase while x remains constant. Taking the positive direction of the x-axis toward the right and of the z-axis (as Rayleigh does) downward, and assigning successive values to t, it is obvious that the earth particle traces out an elliptical path in the clockwise direction.

The direction of propagation of the disturbance is given by holding the argument $(pt + fx)$ constant while t and x vary; hence x decreases as t increases, and the direction of propagation is from right to left.

The motion of the earth particle at the highest point of its path is thus opposite to the direction of propagation of the wave-front, and its path is therefore designated as *retrograde.*

It should be noted that the ratio $Z : H$ of the vertical to horizontal displacements defined above results from the assumption that the medium on the surface of which the waves are propagated is a homogeneous isotropic one, and that for this medium Poisson's ratio (σ) has the value $\frac{1}{4}$.

This ratio is a number expressing the ratio of lateral contraction to longitudinal extension when a bar of the material is strained by forces applied to its ends, and is frequently used as a convenient means of expressing the relation between the elastic constants of a material. The elastic constants λ and μ, usually called Lamé's constants, are generally used in stating the equations of motion in an elastic solid, from which equations (5) and (6) are derived. μ has a direct physical meaning. It is the rigidity, or resistance to change of shape. λ, however, does not have a direct physical significance. It enters a definition of Poisson's ratio, σ,

$$\sigma = \frac{\lambda}{2\,(\lambda+\mu)}$$

and that of another physical constant determinable by experiment, the modulus of compression, or incompressibility, κ,

$$\kappa = \lambda + \tfrac{2}{3}\mu$$

which is a quantity obtained by dividing the measure of a uniform pressure by the measure of the cubical compression which it produces.

Experiments have led to the widespread acceptance of $\frac{1}{4}$ as a close approximation to the value of σ for materials in the earth's outer crust. As a result, it has been assumed that the constants determining Rayleigh-waves are essentially those deduced from the acceptance of $\frac{1}{4}$ as Poisson's ratio. It is obvious, however, that this may not be the case. On the other hand, it is to be noted that no possible value of Poisson's ratio will lead to values of the $Z : H$ ratio less than unity in the case of an isotropic medium.

In the present investigation, the ratio $Z : H$ of the vertical to the horizontal component of motion in the R-waves was found in all cases examined to be less than unity.

Theory shows that for an isotropic medium for which Poisson's ratio is $\frac{1}{4}$, the $Z : H$ ratio in R should be approximately 1·5. We are, however, dealing with a medium which is not isotropic. Quite possibly the modulus of rigidity (μ) is different in the vertical and horizontal directions, and we may expect the modulus of incompressibility (K) to vary with the depth. It may be pertinent to investigate the extent to which the $Z : H$ ratio would be affected by such conditions.

Other investigators have reported somewhat similar results. Mainka, in particular, ([53]), ([54]), has made a large number of observations in this connection. From 280 seismograms, with 534 values for $Z : H$, he found that for about 31 per cent the $Z : H$ ratio lay between ·91 and 1·00, while for 28 per cent it lay between 1·21 and 1·50, with most of the values around 1·3 and 1·4.

Galitzin ([15]) found the $Z : H$ ratio ranged from ·46 to 1·28 with the greatest number of observations between ·7 and 1·0.

Where the quakes used in such measurements are not "end-on" to the recording instruments, however, there may be some doubt as to the accuracy of horizontal component records, as will be discussed later.*

The status of the matter as this investigation appears to leave it may be summarized briefly. The earth particle during the passage of Rayleigh-waves was found, without exception in the present instance, to rotate in a retrograde sense as regards the propagation direction of the waves. This is required by the theory of Rayleigh, but does not seem, so far as the writer can find, to have been previously established explicitly by observational data.

The observed $Z : H$ ratio of displacements is, in all the cases examined, less than unity, and thus disagrees with the theoretical ratio for a homogeneous isotropic medium. It is regarded as possible that this arises from the non-isotropic character of the earth's surface layers.

The relation of rotation sense to propagation direction is suggested as a means of identifying the various *W*-waves which are registered after arrival by the major arc, or after one or more circuits of the globe. It might also be used in trying to establish a propagation direction for microseisms.

There has been no attempt to include this last within the scope of the present study, but a casual application of the test to a few trains of microseisms at Ottawa has indicated distinct possibilities.

R-wave Velocities

As indicated in the study of earth particle paths, the vertical component is the vital criterion in the identification of *R*-waves. In collecting data for the present investigation, the only velocities used were those computed from quakes for which the vertical record at Ottawa permitted a reliable identification of *R*.

The observations of this investigation have been tabulated in six groups, according to the nature of the surface path from epicentre to station. The first group includes continental paths northwest of Ottawa; the second, continental paths south and southwest of Ottawa; the third, Atlantic Ocean paths; the fourth, Pacific Ocean-North America paths; the fifth, Europe-Atlantic paths; and the sixth, isolated exceptions, such as an Africa-Atlantic and an Asia-Arctic-Greenland path. Table VI lists the data. For each velocity, the periods found to exhibit that velocity are shown under the indicated path columns. The quake numbers and distances are used to identify the entries. Only the velocities of centres of energy at the head of well-defined groups were measured. The first period shown is that for which the velocity was computed. The maximum and

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*Love made the following suggestion, from the theoretical standpoint: (47, page 178)

"All the general features of the large waves of earthquakes are represented in the theory suggested by the analogous theory of waves on deep water, except the observed comparative smallness of the vertical motion. Now, if the oscillatory waves which appear to be transmitted over the surface were physically existing simple harmonic wave-trains, this difficulty could only be met by the supposition that adequate instruments for separating the vertical motion from the horizontal, and recording it faithfully, have not so far been devised. But the suggestion which has been made already that these observed oscillations are the result of superposing an infinite number of standing simple harmonic waves, may perhaps furnish a different explanation. Such waves can combine to form progressive oscillatory waves, but we have seen that there is no reason why the ratio of amplitude of the vertical and horizontal component displacements which is characteristic of the constituent standing waves should be maintained in the maxima of the aggregates. The difficulty may, therefore, perhaps be regarded as less serious than it has been thought to be."

This suggestion, however, may lead to greater difficulties than those from which it extricates us. The principle of super-position of simple harmonic waves allows for a combined amplitude greater than that of the constituent waves, as well as one which is less than that of the individual waves. Yet the reported observations of Z : H greater than 1·5 are so few as to be outstanding. If the superposition of simple waves gives the recorded surface motion, it would seem to be entirely likely that the true vertical motion of individual waves is considerably less than that of the recorded group, or centre of energy.

TABLE VI.—R-WAVE VELOCITIES

Velocity	1. Continental Path			2. Continental Path			3. Oceanic Path			4. Oceanic-Continental			5. Oceanic-Continental			6. Oceanic-Continental		
	Northwest			South and Southwest			Atlantic			Pacific-N. America			Atlantic-Europe			Miscellaneous		
	T_o	Quake No.	Distance	T_o	Quake No.	Distance	T_o	Quake No.	Distance	T_o	Quake No.	Distance	T_o	Quake No.	Distance	T_o	Quake No.	Distance
km./sec.			km.			km.			km.			km.			km.			km.
2·50																		
2·51	17−16	1387	7,620															
2·52	−14																	
2·53																		
2·54																		
2·55																		
2·56																		
2·57																		
2·58																		
2·59																		
2·60																		
2·61	....	....	....	17	1353	8,230												
2·62	18	1387	7,620															
2·63																		
2·64	17	1812	8,780															
2·65																		
2·66																		
2·67	18	1974	9,230	19	3,092	3,590												
2·68																		
2·69																		
2·70																		
2·71																		
2·72																		
2·73																		
2·74																		
2·75																		
2·76																		
2·77	? >15	1969	8,860															
2·78																		
2·79																		
2·80	20−17	3551	6,980															
	18−15	2194	7,390															
2·81																		
2·82	17	3341	8,050															

2·83																	
2·84																	
2·85																	
2·86																	
2·87																	
2·88																	
2·89																	
2·90																	
2·91																	
2·92	20	1974	9,230														
2·93	20	1446	7,380														
2·94																	
2·95																	
2·96	20–19	3161	9,580											(Greenland)			
2·97													13	1274	4,450		
2·98																	
2·99																	
3·00	24–22 –17	2194	7,390														
3·01																	
3·02	24	2194	7,390														
3·03	19–14	1812	8,780														
3·04																	
3·05																	
3·06	18–15	3540	7,000														
	18–15	3551	6,980														
3·07																	
3·08	18	1887	7,200										25–20	3117	7,620		
3·09	20–18	3542	6,950														
3·10																	
3·11																	
3·12	24	2616	7,020														
3·13	24–22	3161	9,580	26–20	3317	8,920											
	30–24	1387	7,620														
3·14																	
3·15																	
3·16																	
3·17				25–20	3314	8,980											
3·18	20	1462	5,520														
				22–13	1715	3,900											
3·19				20–17	1353	8,230											
				25–20 –17	3303	7,550											

TABLE VI.—R-WAVE VELOCITIES—*Continued*

Velocity	1. Continental Path			2. Continental Path			3. Oceanic Path			4. Oceanic-Continental			5. Oceanic-Continental			6. Oceanic-Continental		
	Northwest			South and Southwest			Atlantic			Pacific-N. America			Atlantic-Europe			Miscellaneous		
	T_o	Quake No.	Distance	T_o	Quake No.	Distance	T_o	Quake No.	Distance	T_o	Quake No.	Distance	T_o	Quake No.	Distance	T_o	Quake No.	Distance
km./sec.			km.			km.			km.			km.			km.			km.
3·20	25	3542	6,950	20−18	1351	8,060										24−15	(Lena R.) 2992	7,020
	24−15	2992	7,020	20−18	1354	8,080												
				22	3139	5,680												
3·21																		
3·22				24−16	1706	3,900												
3·23	22−20	3540	7,000										Harv. 23−18	3437	9,620			
	25−22	3551	6,980										Ott. 23−18	3437	9,620			
3·24																		
3·25																		
3·26	30	1974	9,230															
3·27	27−25	3543	6,950															
3·28													22	2931	7,950			
3·29																		
3·30				24−10 −13	2039	3,980												
3·31													27−19	1885	8,740			
3·32																		
3·33																		
3·34																		
3·35																		
3·36																		
3·37																		
3·38	(20+)	2194	7,390	24	3317	8,920												
	30	2616	7,020															
	(21−17)	1417	7,390															
3·40	30−24	1387	7,620															
3·41																		
3·42	24−20	1917	7,320										25 Harv.	3437	9,620			
3·43	20	1887	7,200										25 Ott.	3437	9,620			
	26	1462	5,520															
3·44																		

3·45				30−22	1351	8,060												
3·46																		
3·47																		
3·48													25−19	1274	4,450			
3·49																		
3·50										23	2413	13·050						
3·51				$W_2$28	1353	31·770				*M*								
3·52														Asia				
3·53																		
3·54													32−27	1815	10,620			
3·55																		
3·56																		
3·57	30−20	3542	6,950															
3·58	40−29	3161	9,580	48−24	3185	3,700												
				32	2356	3,700												
3·59																		
3·60				38−20	3303	7,550												
3·61																		
	Harv. Ott. (Atl.) 500																	
3·62	28−33	3544	(4,400)	34−26	1353	8,230												
3·63	35−27	3551	6,980															
3·64				35−22	3314	8,980												
3·65				44−24	3092	3,590												
3·66							23−18	3352	7,350									
3·67	40	3161	9,580	37−21	1961	4,140												
	40−12	3341	8,050															
3·68	37−26	3540	7,000															
	34	3543	6,950										30	1885	8,740			
3·69				44−20	3263	3,700												
3·70				44−24	1763	3,690												
3·71				−16														
3·72																Africa-Atl. N. A.		
3·73																22−16	2570	16,100
																M16		
3·74																		
3·75	50−41	1812	8,780															
	−27																	
3·76																		
3·77																		
3·78										$W_2$21	2413	26,950						
3·79																		
3·80				50−20	3344	3,740				(43)	2413	13,050						

TABLE VI.—R-WAVE VELOCITIES—*Concluded*

Velocity	1. Continental Path			2. Continental Path			3. Oceanic Path			4. Oceanic-Continental			5. Oceanic-Continental			6. Oceanic-Continental		
	Northwest			South and Southwest			Atlantic			Pacific-N. America			Atlantic-Europe			Miscellaneous		
	T_o	Quake No.	Distance	T_o	Quake No.	Distance	T_o	Quake No.	Distance	T_o	Quake No.	Distance	T_o	Quake No.	Distance	T_d	Quake No.	Distance
km./sec.			km.			km.			km.			km.			km.			km.
3·81										NW						Africa-Atl. N. A.		
										36–24	2630	14,000				21	2045	16,000
										M						M		
3·82										$W_2$24	2630	26,000						
3·83													35	1885	8,740			
3·84										34–25	2307	9,400						
										–19								
										M M								
										W_5	2630	94,000						
3·85							34–19	1910	3,530	35–20	2028	13,300						
										34–22	3083	13,400						
3·86							33–17	3544	4,400									
3·87																		
3·88	50	3551	6,980							40–33	2336	13,200						
										–27–20				Asia				
								(Harv.)										
3·89							28–17	3544	3,900	W_4	2630	66,000	41–38	1815	10,620			
							28–16	3368	4,900									
3·90	60–30	1387	7,620				37–15	1536	3,600									
							37–15	1537	3,600	38–20	2697	13,600						
										–17								
3·91							26–19	2250	4,900									
							30	3352	7,350									
3·92																		
3·93																		
3·94																		
3·95										(W_2)								
										23–19	3083	26,600						
3·96																		
3·97																		
3·98																		
3·99																		

4·00																		
4·01																		
4·02																		
4·03																		
4·04																		
4·05																		
4·06																		
4·07				50—20	2350	3,900												
4·08																		
4·09																		
4·10													37—30	2931	7,950			
4·11																		
4·12																		
4·13																		
4·14																		
4·15																		
4·16																		
4·17																		
4·18																		
4·19																		
4·20																		
Quakes used	2639, 3372, 2973, 1996, 3192, 1462, 2890, 3370, 3381, 1887, 2616, 2617, 2618, 2619, 3540, 3542, 3543, 3551, 1387, 1386, 3024, 1417, 2194, 1866, 1917, 1446, 3341, 3161, 1969, 1812, 1974. Total..........31			1351, 1353, 1354, 1356, 1706, 2245, 2291, 2779, 3139, 3092, 3303, 3314, 3317, 1961, 1715, 3690, 2350, 2356, 3185, 3263, 3292, 3344. Total..........22			1556, 1537, 1910, 2151, 2250, 2921, 3352, 3368, 3544. Total.......... 9			2028, 2307, 2697, 2336, 2413, 3083, 2630, 2900. Total.......... 8			2931, 1815, 1885, 3437, 1274, 3117. Total.......... 6			2045, 2570, 2992. Total.......... 3		
Maxima at T_e =	15, 17, 18, 20, 23, 30, 35.			20, 22, 23, 25, 30, 34, 35.			Maxima in general not defined — uniformly lessening peaks. (Absence of strong enough Q to cause interference?)			17, 19, 25, 20, 24						16, 21.		
No clearly marked surface phases on				2779, Distance 8,320 km.			2151, Distance 3,200 km.											
No R identified on				1356, Distance 8,020 km. 2245, Distance 3,050 km.														
No Q identified on				1354, Distance 8,080 km. 2350, Distance 3,900 km. 3185, Distance 3,700 km.			3544, Distance 4,400 km. 1910, Distance 3,530 km.									2045, Distance 16,000 km. 2570, Distance 16,100 km.		

minimum apparent periods in some of the wave groups are also shown. They were recorded on the possibility that the range of periods might be found to influence the velocity of the head of the train. No such correlation seems to be established.

The velocities observed are, in all probability, group velocities. No attempt has been made to determine statistical or graphical averages. Apparent periods in the early portions of wave trains cannot be determined with an accuracy which warrants the arbitrary statement that a given period exhibits a definite velocity and no other. Accordingly, it is felt that the point has not yet been reached where it is safe to attempt to determine exact velocity laws from the data available. Another important reason for listing the data exactly as observed, without combining to obtain averages, is that it is felt that only by some such method will local effects of path on velocity be discovered.

Within given path groups, notably 1 and 2, for which there are more observations, *there is a distinct tendency for velocity to increase with period.* There is strong evidence for the reality of this phenomenon in spite of overlapping of values and general haziness of transition zones, which are possibly introduced in part by uncertainties of observation, by local path differences, or by errors in the computations of distance and time of origin.

There is, further, a marked correlation between the values obtained for NW and S continental paths, indicating a similarity which might be expected, but should not be assumed simply because both paths are continental.

The values for the Atlantic, while not numerous, are well enough determined to clearly indicate a markedly higher velocity for those paths than for the continental ones. They are, in fact, of the same order of magnitude as for the Pacific-North America paths.

Number 3544 was well recorded at both Harvard and Ottawa on the same great circle from the epicentre, and merits special attention. The apparent velocity of R from the epicentre to Harvard was 3·89 km./sec. The first waves at Harvard had an apparent period of 28 seconds. The beginning of the same train at Ottawa showed an apparent period of 33 seconds, but a velocity from Harvard to Ottawa, using the epicentre-Harvard value and Harvard-Ottawa value weighted according to the respective distances, was computed to be 3·86 km./sec., the exact value observed for the epicentre to Ottawa path. It will be noted that the velocity of 3·62 km./sec. from Harvard to Ottawa is in line with others for the same periods over total continental paths (columns 1 and 2 of Table VI). This gives direct evidence of the difference between Atlantic and continental velocities.

At the bottom of each column in Table VI are listed the periods at which concentrations of energy appeared on the seismograms. It may be noted that in the two continental groups there is an absence of periods between 25 and 30 seconds. Whether or not this has a real physical significance could not be estimated from the data of the present study.

Wrinch and Jeffreys ([132]) suggested the possibility that R-wave velocities might yield information concerning the thickness of a postulated surface layer of the crust, that is, the so-called granitic layer. It was suggested that, if the lower layers transmitted vibrations with greater velocities than the outer, R-waves of increasing wave length would derive increasing velocities from the underlying higher-speed layers as their effects outweighed those of the surface layers.

If the change in velocity in a lower layer were sudden, the R-wave velocities might be expected to show a discontinuity of velocity in the vicinity of the periods which first penetrated the high-speed layer sufficiently to have their velocity controlled by it. No such discontinuity in the velocities appears in Table VI. Actually, as can be clearly seen, the data are too variable to permit clean-cut quantitative inferences.

Considerations of *R*-wave velocities must include possibilities of changing wave form in the course of propagation, as discussed by Sezawa ([91]).

Macelwane ([48]) in a study of records of the California Earthquake of 1922, January 31, reported a progressive lengthening of period and wave length in "*M*" waves with distance, while the velocity remained approximately the same. This finding, however, cannot be compared directly with the results of the present investigation. It applies to "*M*" which, as shown in a later section of this report, is not in general identifiable as *R*.

Gutenberg ([23 24 29b]) appears to be the only previous investigator to have published observations of Rayleigh-wave velocities in terms of period and path, resulting in evidence that they are subject to dispersion. His results were obtained, in the main, from studies of a few individual quakes as recorded at many stations, such as the quakes of 1927, June 26, in the Tonga Deep, 1923, September 1 and 2, in Japan, and others. The paths on which he reports are not directly comparable with the ones studied here. He finds, however, over all paths, an increase of velocity with greater periods. His tables, also, show a distinctly higher velocity for Atlantic Ocean-Europe paths than, for example, for Eurasian paths. Pacific paths show the highest velocities, but they are only slightly in excess of the Atlantic values which in this case, it must be remembered, include a portion of continental path.

In calculating the apparent velocities from a computed epicentre, there is, of course, uncertainty as to the exact point at which the *R*-waves can be regarded as having started. Investigations of Nakano ([64]) indicate that for an assumed depth of focus of 30 km., Rayleigh-waves may be expected to originate from 20 to 70 km. from the epicentre. Since the limits within which the epicentres are determined are no closer than this, *R* may be considered, for purposes of velocity computations at a distance, as having originated practically at the epicentre.

The effect of focal depth has been studied by Banerji ([4]), who demonstrates that the amplitudes of *R* decrease as the depth of focus increases. Several records were found in the present study which at Ottawa showed practically no clearly-defined *R*-waves. It is likely that the absence of *R* in those cases offers a qualitative indication of abnormal depth of focus.

Finally, consider Table VI, column 4, velocities 3·78 and 3·80. It will be noted that while the *R*-waves of 2413 with periods of the order of 43 seconds display a velocity of 3·80 km./sec., the W_2-waves from the same quake, with periods of 21 seconds, show a velocity of 3·78 km./sec. (*W*-waves, in fact, are generally notable for their uniformity of period and velocity. An explanation of this was suggested by Gutenberg in a paper, "The Process of Formation of Seismic Surface-waves," translation by Ernest A. Hodgson, which was presented before the New York 1929 meeting of the Eastern Section of the Seismological Society of America, and is to be published in the bulletin of the society.) Fig. 2 illustrates a possible explanation of this apparent anomaly. The $Z : H$ ratio in the *R*-wave section is of the order of ·5, whereas it is practically 1·0 in the Rayleigh-wave groups of W_2. There might seem, then, to be a possibility that a relationship exists between the $Z : H$ ratio and the ratio of depth of penetration to wave length. It might be found that, though the same velocity is shown by different periods, a given period does not at all times represent the same depth of penetration, hence its velocity is not always controlled by the same materials.

Group Velocity

Group velocity undoubtedly plays an important rôle in determining the character of *R*-wave oscillations as recorded at seismograph stations. The seismogram, in all probability, registers the apparent motion of centres of energy which have been propagated with the appropriate group velocity. The effect on the $Z : H$ ratio of amplitudes, as discussed by Love, has already received mention (page 287). A discussion of what is meant by group velocity can be found in such texts as those of Gutenberg ([29]), Haas ([31]), Lorentz ([46]), and others.

Rayleigh-waves—Horizontal Component Records

Most of the reduced earth amplitude graphs were made for the specific purpose of attempting to determine the reality of certain apparent phases or groups in the *R*-waves. The study resulted in some rather definite indications concerning the significance of horizontal component records of the so-called maximum portions of seismograms, which are generally indicated by reporting stations as "*M*."

When a quake is "end-on" relative to the orientation of the horizontal component instruments, there is a definite correlation between the onset of *R* as indicated by the vertical, and the beginning of the longitudinal motion on the proper horizontal component instrument. Figs. 18a and 23 illustrate this. When it is not "end-on," however, the horizontal records do not in general indicate the beginning of *R*. Figs. 8, 9, 10, 11, 13, and 21 are examples. In such cases, moreover, the horizontal records (reduced to true earth amplitudes) do not show maxima with any consistent relation to the actual *R*-wave maxima as indicated by the vertical.

No identity was established between apparent surface phases at varying distances, other than similar groupings where periods were comparable. 3540 and 3551 (7,000 km. NW.), and 1353 (8,230 km. S.) illustrate similar groups of this kind. (Figs. 10, 11, 18.)

Fig. 8 offers a comparison of the Harvard and Ottawa records of 3542—the stations lying on the same great circle with the epicentre. Even reduced to true earth amplitudes they display discordance of wave form. The original seismograms show still greater apparent discrepancies. In contrast to this, fig. 6 shows the reduced amplitudes for 3544, in which transverse surface-waves seemed to be almost entirely absent. Here *R*-waves were being recorded essentially without the interference of other types of motion, and the horizontal records were reliable. In this connection, number 1910, recorded five years earlier, from a neighbouring epicentre, distance 3,530 km., is practically a facsimile copy of the Harvard record of 3544, for which the Harvard distance was 3,800 km.

The findings apply to the records of horizontal component instruments which are not oriented in line with or normal to the direction of propagation of an earthquake disturbance. The evidence seems to indicate that the so-called "maxima" in such cases owe their character in general to fortuitous fluctuations in the phase, period, and amplitude of the transverse and longitudinal motions which combine to cause them. As a result, unless a station is equipped with a vertical seismograph, its records do not give a reliable indication of the onset, duration, or character of R, for quakes which are not "end-on" with respect to the instruments' orientation.

This would suggest that *the reading of "M" for the bulletins of seismograph stations is meaningless*. Only when the azimuth of the quake is "end-on" can an accurate determination of true amplitude maxima be made, and those amplitudes be resolved in terms of transverse and longitudinal motions. It is, of course, well known that *trace* maxima, in any case, are a definite function of the recording instrument's period and consequent magnification of different earth periods. When a quake is not "end-on" interference between longitudinal and transverse motions of the ground, if these are of different periods, gives a trace pattern that cannot be untangled in terms of true longitudinal and transverse motions.

From this, it will be clear that no part of the horizontal record of a quake whose azimuth was not one of the cardinal instrument directions can be selected with assurance as representative R-wave registration—there is at practically all times a transverse element of unknown magnitude present.

Complication arises from the problem of phase as discussed previously. When the periods of Q and R are comparable in magnitude, as appears to be the case frequently, if not invariably, in the later parts of seismograms, the problem of phase is unimportant. If, however, in earlier portions of Q and R, their periods differ to any marked extent, and a single instrument is registering a component of each, the instrument will have one phase lead for Q and another for R. It would, accordingly, be practically impossible to accurately resolve the trace in terms of components of Q and R. This point is further amplified in the discussion of record character, below.

Record Character in Connection With Place of Origin

In the course of the present study, a few opportunities were presented to compare records from the same and neighbouring epicentres, in the light of the opinion held by some station seismologists that certain epicentral regions yield quakes of characteristic types.

Fig. 10a shows the EW record of 3540 superposed on the same component of 3551. The practically point-for-point identity of the two records in period and relative amplitude is remarkable, though the energy of 3540, as evidenced by maximum amplitudes, is very much less than that of 3551.

A second case, not illustrated, was mentioned above in connection with quakes 1910 and 3544. 1910, distance 3,530 km., was recorded at Ottawa 1924, October 14. 3544 was registered at Ottawa and Harvard on Milne-Shaw seismographs adjusted to the same constants, on 1929, July 6. The distance from Ottawa was 4,300 km., from Harvard, 3,800 km. The epicentres were in the same general region in the Atlantic Ocean. Both Ottawa and Harvard records of 3544 are identical in character with that of 1910.

Numbers 2623 and 2624 presented an interesting case of two shocks almost exactly an hour apart, from approximately the same origin. Their records, one immediately below the other on the seismograms for that day, are almost perfect twins. Fig. 3 illustrates this.

On the other hand, 1763 and 2350, computed to have practically the same epicentre, are totally different in character.

Two series from the same region in the Aleutians provided an interesting comparison. 2616, 2617, 2618, and 2619 followed each other in close succession, 1926, October 13 and 14. 3540, 3542, 3543, and 3551 occurred in the same region, 1929, July 6 and 7. The records are similar, though not identical, in character.

Number 2039, 1925, March 29, was recorded at Ottawa and Rio de Janeiro at distances of 3,980 and 4,400 km. respectively. (See fig. 4.) The epicentre was about S.10°W. from Ottawa, and NW. from Rio de Janeiro. The EW Milne-Shaw component records at the two stations present a striking contrast. The instruments were operating with the same constants. The record of the surface-waves at Ottawa is quite regular, with a maximum period of 21 seconds well marked. At Rio de Janeiro, it is much less regular, with a period of the order of 9 seconds. *The Rio de Janeiro record, in fact, might serve as a fair type representative of Ottawa records of quakes from the NW. or SW. at comparable distances.* In fig. 4, the Ottawa record of No. 1996, from the NW., is shown for comparison.

This instance of No. 2039 suggests that either there are marked differences between the epicentre-Rio de Janeiro path and the epicentre-Ottawa path which merit investigation, or the orientation of instruments has a much more fundamental influence on the utility of horizontal component seismograms than has been recognized. It is proposed at Ottawa to re-orient the Milne-Shaw horizontal instruments at an early date to place them in line with and normal to the many quakes which originate along the great circles northwest and southwest of the station, with a view to comparing records thus obtained with those registered on NS and EW instruments at present.

Without multiplying examples further, the indications observed may be summarized briefly. It seems clear that quakes from exactly the same epicentre (as nearly as it can be determined) do, on occasion, give practically identical records at Ottawa. It cannot be said, however, from the observations made in this investigation, that there is any notable inherent identity between the surface phases of quakes from a given region, or difference between those of comparable distances from different epicentral regions. It is believed that many apparently unique characteristics are for the most part functions of the azimuth of the quake from Ottawa, coupled with the orientation of the instruments.

Summary

A study of earthquake surface-waves at a distance from the epicentre was made from the records of a single station. It was found desirable to concentrate chiefly on Rayleigh-waves, concerning which there seem to be fewer empirical data than for most of the other wave types recorded by seismographs.

The data for the investigation were taken, with five exceptions, from records of the Ottawa seismograph station. Four records supplementing these were obtained at the Harvard seismograph station, and one at Rio de Janeiro, on Milne-Shaw seismographs adjusted to the same constants as the instruments of that make in service at Ottawa. The records from Ottawa, obtained over a period of years, offer for study earthquakes from all parts of the globe, registered under identical conditions by the same instruments, with constants well determined, and with accurate time registration.

Records for the period between 1922 and 1929 were examined, and 127 of the quakes best recorded were selected for study.

In the discussion of the recording instruments, a special attention was accorded the constants of, and reliability of records from, the vertical component instrument.

Portions from the surface phases of fifty-six components, representing eighteen quakes, were reduced to true earth amplitudes, for purposes of rigorous comparison. The accuracy of this work is discussed.

It has been known for some time that there are at least two distinct types of surface waves: the Q, "querwellen," or transverse wave, with no vertical component; and a type with dominantly longitudinal and vertical displacements. No satisfactory evidence was found, in the present investigation, of the existence of other types at a recording station distant from the epicentre. The longitudinal-vertical type has generally been assumed to represent a motion first described mathematically by Lord Rayleigh, in 1885. So far as could be found, however, no explicit confirmation of this identity between observation and theory has been presented in connection with the fundamental relationship between the rotation sense of the earth particle and the propagation direction of the disturbance. Accordingly, such confirmation was sought in the present study.

The earth particle during the passage of Rayleigh-waves was found, without exception in the cases studied, to rotate in an elliptical path in a retrograde sense as regards the propagation direction of the disturbance. The same was found to be true for W_2-waves which, arriving from the opposite direction, exhibit a rotation sense which is the reverse of that in R. It is shown that this is required by the theory of Rayleigh.

The $Z : H$ ratio of vertical to horizontal displacements differs from the ratio predicted by theory for an isotropic medium. This result is in part confirmed by other investigations. It is regarded as possible that the disagreement arises from the non-isotropic character of the medium.

The relation of rotation sense to propagation direction is suggested as a means of identifying the various W-waves which are registered after arrival by the major arc, or after one or more circuits of the globe. It might also be used in trying to establish a propagation direction for microseisms.

There was no attempt to include this last within the scope of the present study, but a casual application of the test to a few trains of microseisms at Ottawa indicated distinct possibilities.

Rayleigh-wave velocities were studied in terms of period and path, using only those computed from quakes for which the vertical record at Ottawa permitted a reliable identification of R. These in all probability represent group velocities. No attempt was made to determine statistical or graphical averages, since it is felt that the point has not yet been reached where it is safe to attempt to determine exact velocity laws from the data available.

It was found that there is a distinct tendency for longer periods to exhibit greater velocities, that is, for the waves to be subject to dispersion.

There was, further, a definite correlation between the values obtained for northwest and south continental paths, while the values for the Atlantic indicated a markedly higher velocity than for continental paths.

Most of the reduced earth amplitude graphs were made for the specific purpose of attempting to determine the reality of certain apparent phases or groups in the surface-waves. The findings applied to the records of horizontal component instruments which are not oriented in line with or normal to the direction of propagation of an earthquake disturbance. The evidence indicated that the so-called "maxima" in such cases owed their character, in general, to fortuitous fluctuatious in the phase, period, and amplitude of the transverse and longitudinal motions which combined to cause them. As a result, unless a station is equipped with a vertical seismograph, its records do not give reliable indications of the onset, duration, or character of R, for quakes which are not "end-on" with respect to the instruments' orientation.

This would suggest that, except in certain special cases, the reading of "M" for the bulletins of seismograph stations is meaningless.

It seems clear that no part of the horizontal record of a quake whose azimuth was not one of the cardinal instrument directions can be selected with assurance as representative R-wave registration—there is at practically all times a transverse element of unknown magnitude present.

In the course of this study, a few opportuuities were presented to compare records from the same and neighbouring epicentres, in the light of the opinion held by some station seismologists that certain epicentral regions yield quakes of characteristic types. It was found that quakes from exactly the same epicentre (as nearly as it can be determined) do on occasion give practically identical records at Ottawa. It cannot be said, however, from the observations made in this investigation, that there is any notable inherent identity between the surface phases of quakes from a given region, or difference between those of comparable distances from different epicentral regions. It is believed that many apparently unique characteristics are for the most part functions of the distance, the azimuth of the quake, and the orientation of the instruments.

Lastly, the problem of instrumental orientation seems to assume important proportions. Horizontal component seismographs do not appear to give satisfactory records of all the earth vibrations reaching them from a given quake unless they are in line with and normal to the epicentre-station great circle. This is particularly true for surface waves, but it should not be surprising to find it true to a greater or less extent for other phases.

For this reason, it is suggested that recording stations, to render optimum service, should orient at least some of their instruments with reference to one or more epicentral regions from which most of their records are obtained, rather than in the traditional NS-EW planes.

TABLE VII.—SEISMOLOGICAL NOTATION EMPLOYED

ORIGIN OF THE DISTURBANCE

Focus	The exact place at which the disturbance originated. Generally beneath the surface of the earth. Theoretically regarded as practically a point.
Epicentre	A theoretical point (?) on the earth's surface, vertically above the focus.

WAVE GROUPS OR PHASES

P	Primæ; first preliminary tremors; longitudinal body waves that have penetrated below the outermost surface layer, following the shortest-time path from focus to station.
S	Secundæ; second preliminary tremors; transverse body waves that have penetrated below the outermost surface layers, following the shortest-time path from focus to station.
SS	S reflected once at the earth's surface between the focus and recording station.
SSS	S reflected twice at the earth's surface between the focus and recording station.
SSSS	S reflected three times at the earth's surface between the focus and recording station.
Q	Querwellen, or transverse surface-waves, with no vertical component of motion.
R	Rayleigh-waves; surface-waves with a vertical component and a horizontal longitudinal component; first discussed mathematically by Lord Rayleigh (69).
L	Long-waves; an indeterminate designation for waves, presumably of the surface groups, whose exact character is uncertain.
W_2	Surface-waves recorded after travelling by the major arc from the epicentre to the station.
W_3	Surface-waves recorded after travelling by the minor arc, epicentre to station, and one complete circuit of the earth.
W_4	W_2-waves after another complete circuit of the earth.
W_5	W_3-waves after another complete circuit of the earth.

NATURE OF THE MOTION

A	Amplitude: either *(a)* amplitude of the earth motion measured from the position of equilibrium in microns, + toward the north, east, or zenith; − toward the south, west, or nadir; or *(b) when so marked*, the *trace* amplitude or half range of movement on the record, measured from the median line, in millimeters.
μ	Micron; 1/1000 of a millimeter.
T_e	Period of earth motion.

DEDUCED DATA

h, m, s	Hour, minutes, seconds; Greenwich Mean Time (GMT), midnight to nidnight, 00h to 23h.
O	Time of the earthquake at the focus.
V	Arcual distance from the epicentre to the station.

CONSTANTS OF THE SEISMOGRAPH

T_0	Period of the seismograph.
V	Static magnification.
V_d	Dynamic magnification.
ϵ	Damping ratio; ratio of successive damped amplitudes.
r	Half width of zone within which friction will completely arrest the recording system. Expressed in centimeters.
R	Friction of a recording system, in dynes. (This is rarely used, and where it does occur would, by reason of the context, scarcely be confused with the symbol for Rayleigh-waves.)

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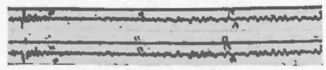
Milne-Shaw No. 17 E-W
Damping ratio 20:1



Milne-Shaw No. 23 E-W
Damping ratio 5:1
S and L phases of small quake
May 4, 1923
Constants otherwise the same

FIGURE 1
Number 1462

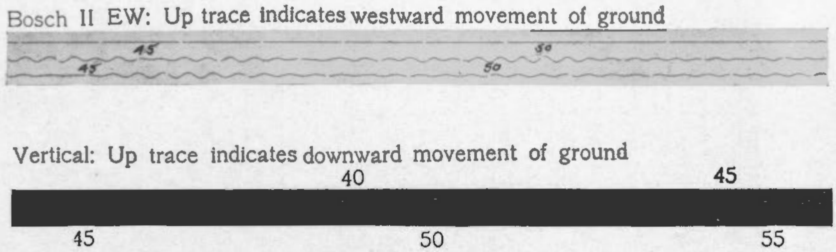


FIGURE 2
Number 2413

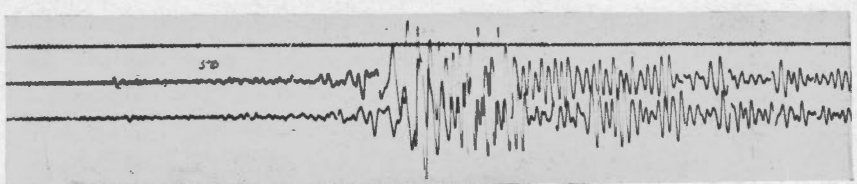


FIGURE 3
Numbers 2623 and 2624

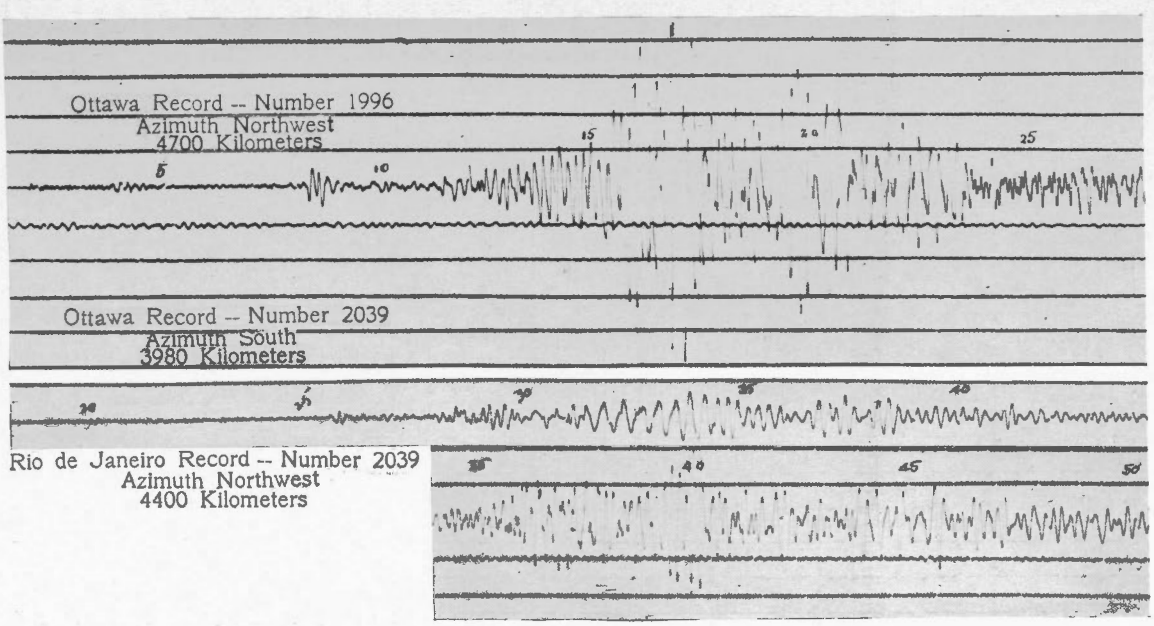


FIGURE 4

14653—6

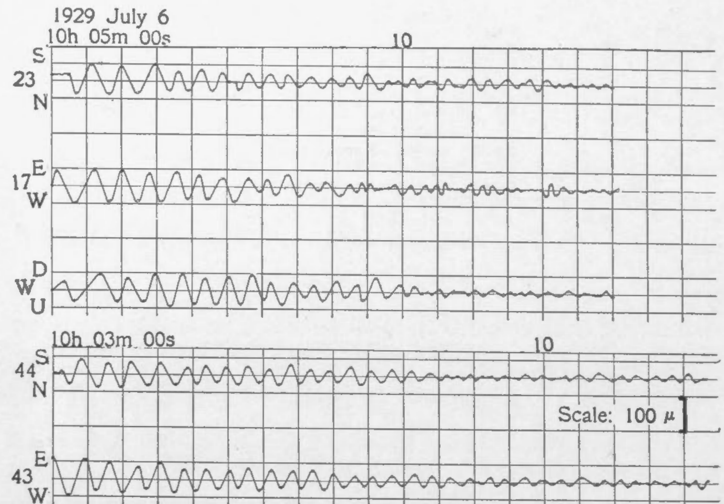


FIGURE 6
Earth Amplitude Graph
Number 3544

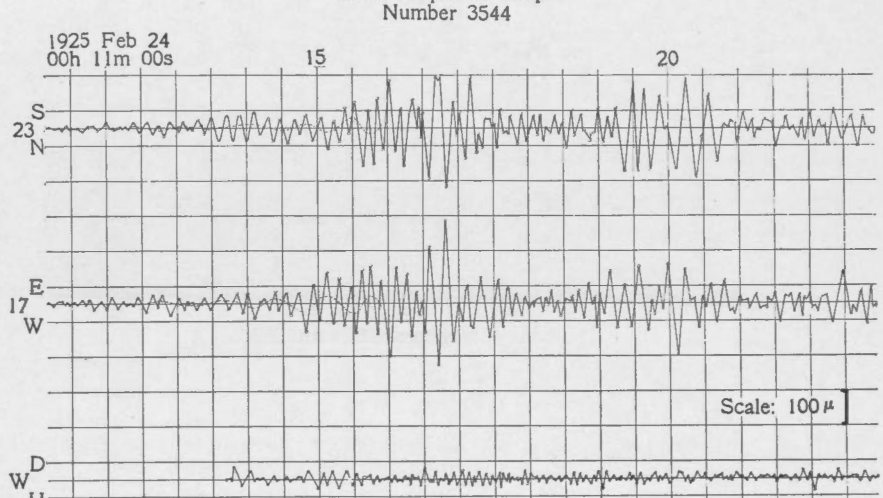


FIGURE 7
Earth Amplitude Graph
Number 1996

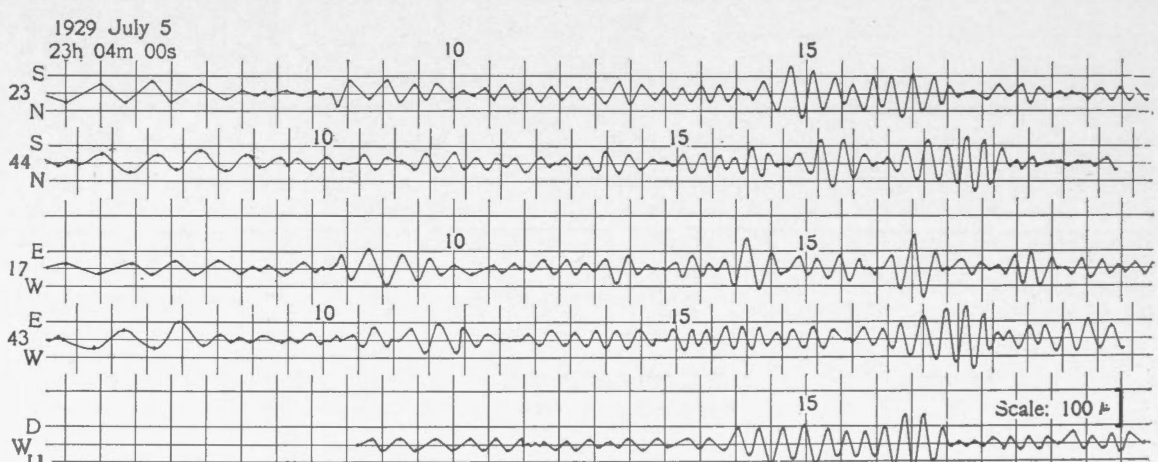


FIGURE 8
Earth Amplitude Graph
Number 3542

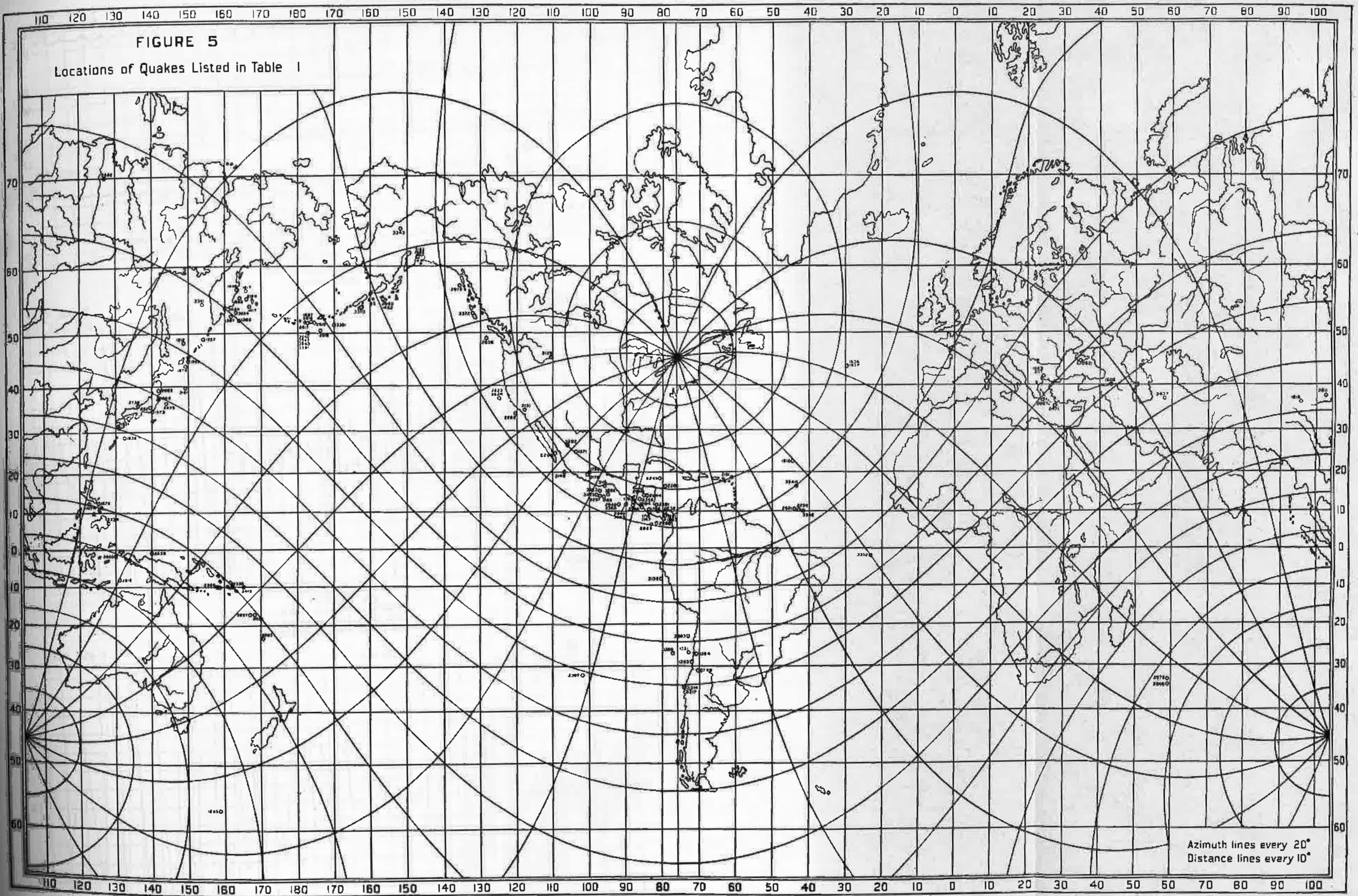


FIGURE 5
Locations of Quakes Listed in Table I
Azimuth lines every 20°
Distance lines every 10°

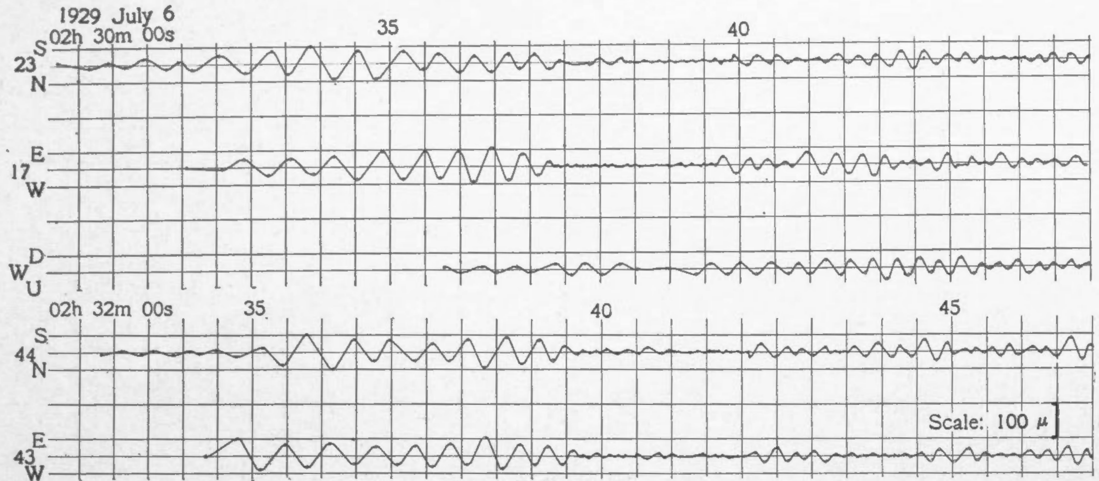


FIGURE 9
Earth Amplitude Graph
Number 3543

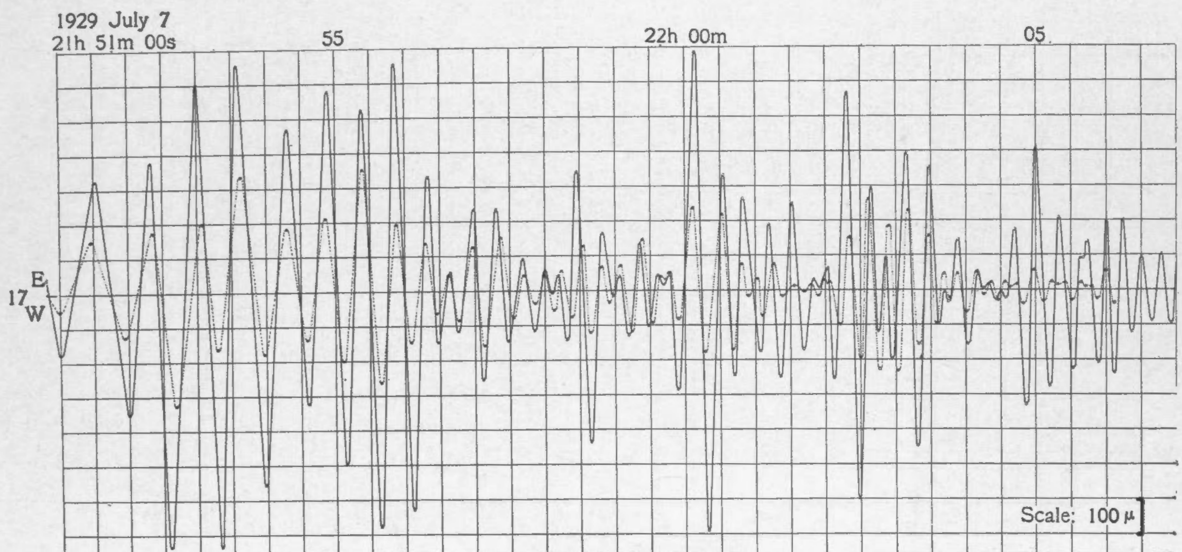


FIGURE 10a
Earth Amplitude Graphs
Number 3551 solid line
Number 3540 dotted line

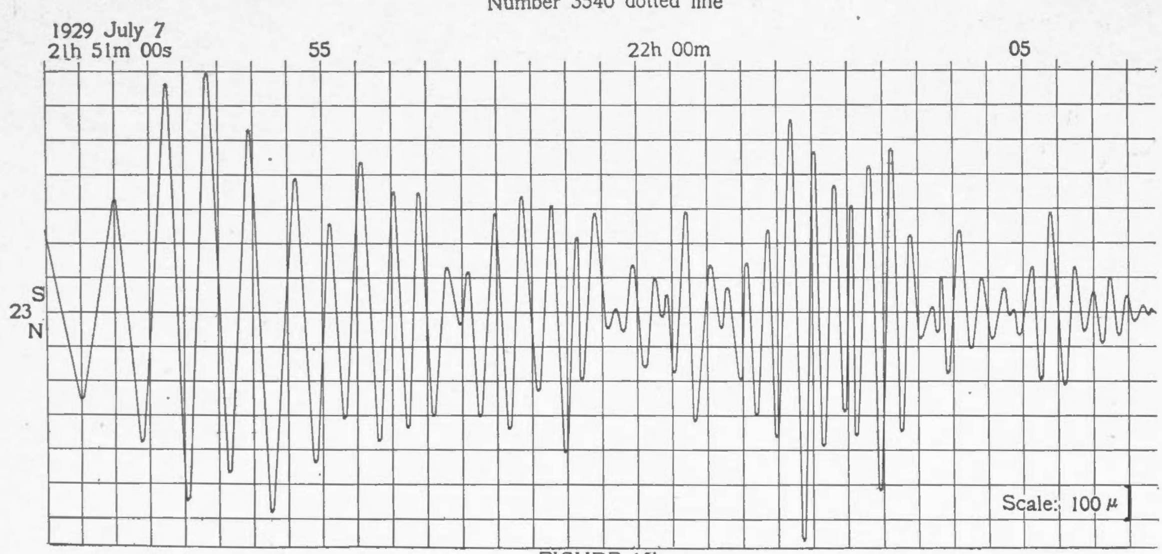


FIGURE 10b
Earth Amplitude Graph
Number 3551

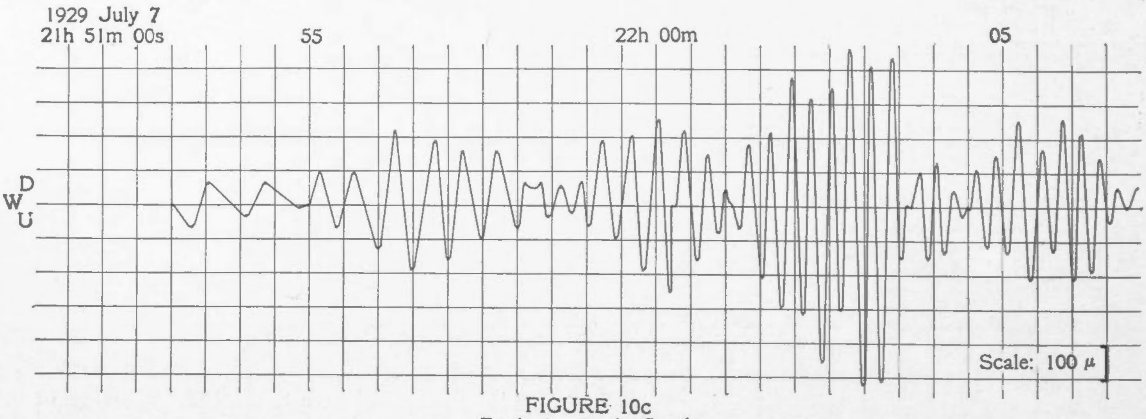


FIGURE 10c
Earth Amplitude Graph
Number 3551

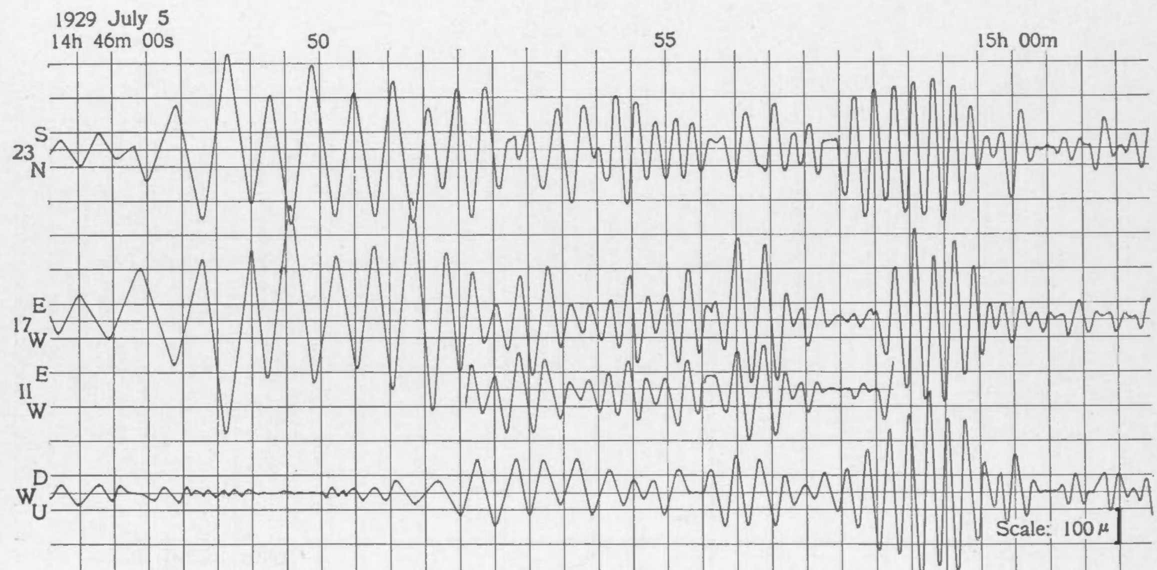


FIGURE 11a
Earth Amplitude Graph
Number 3540

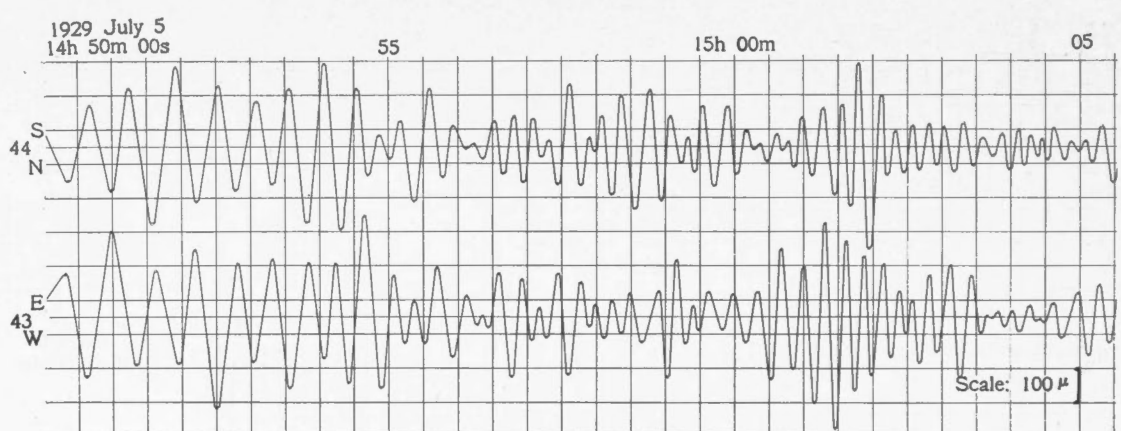


FIGURE 11b
Earth Amplitude Graph
Number 3540

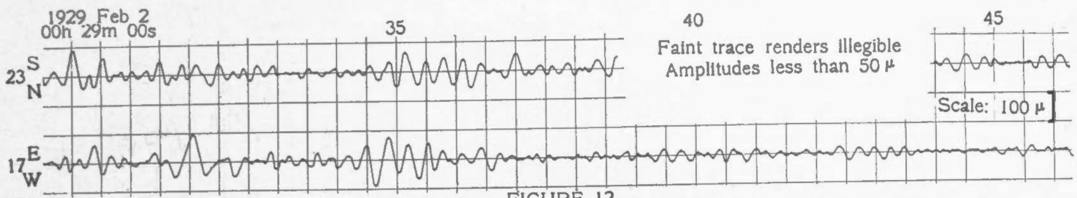


FIGURE 12
Earth Amplitude Graph
Number 3352

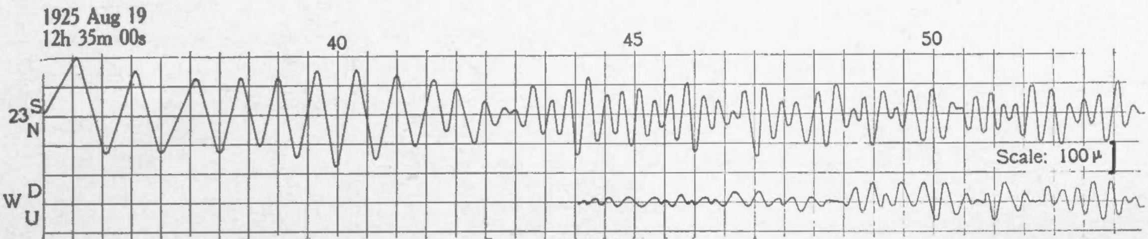


FIGURE 13
Earth Amplitude Graph
Number 2194

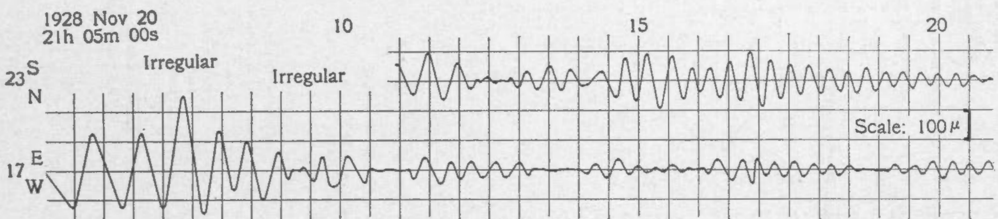


FIGURE 14
Earth Amplitude Graph
Number 3303

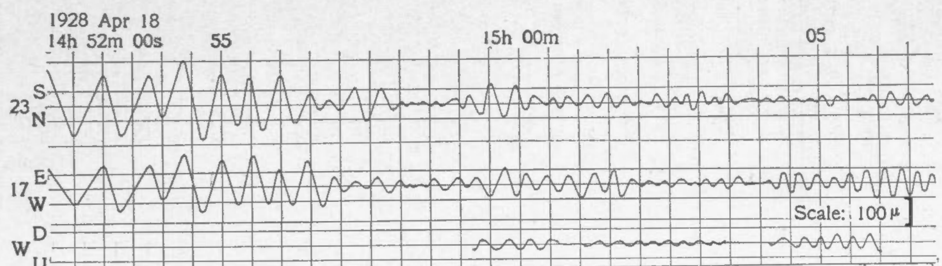


FIGURE 15
Earth Amplitude Graph
Number 3117

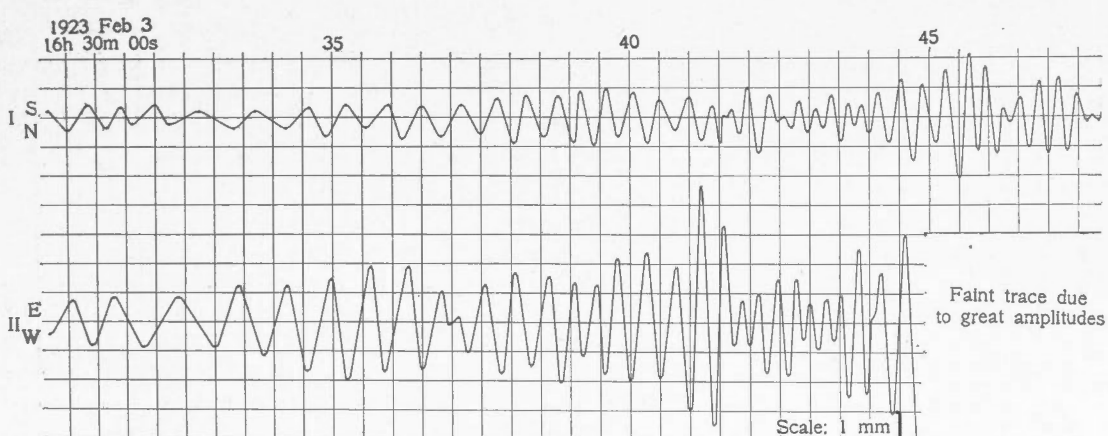


FIGURE 16
Earth Amplitude Graph
GREAT QUAKE
Number 1387

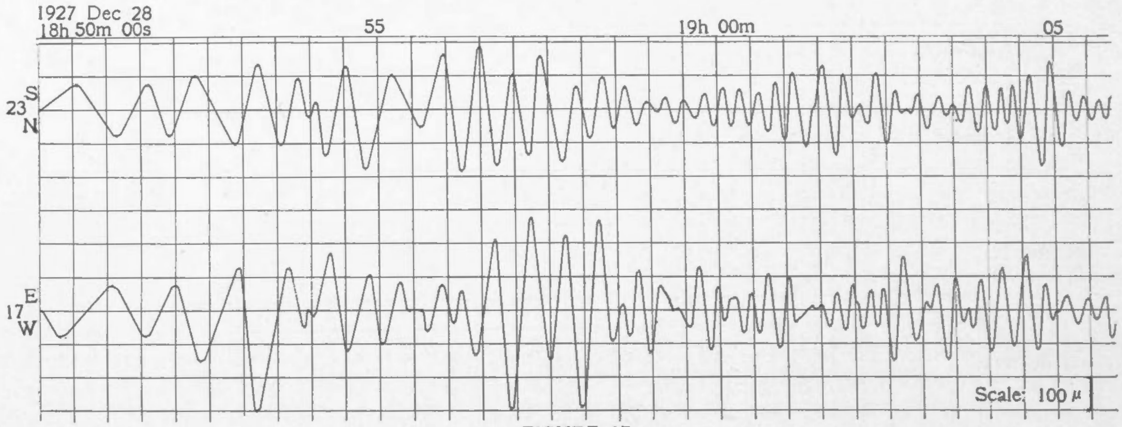


FIGURE 17
Earth Amplitude Graph
Number 3024

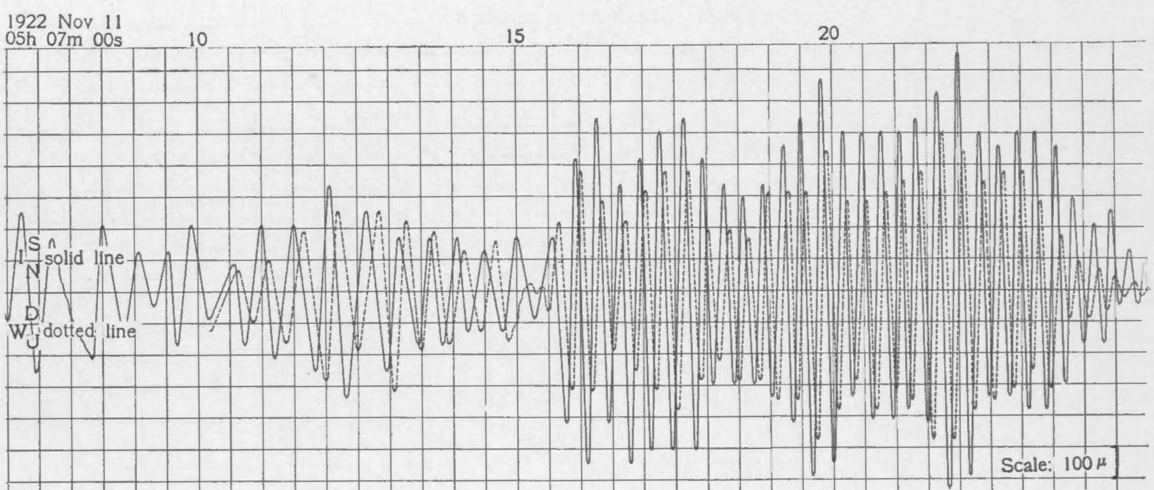


FIGURE 18a
Earth Amplitude Graph
Number 1353

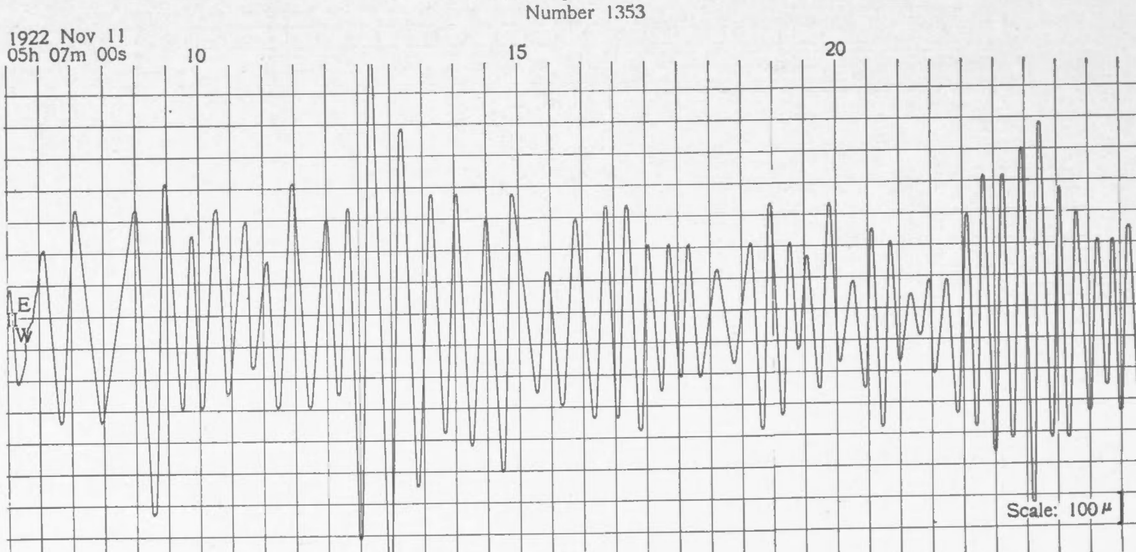


FIGURE 18b
Earth Amplitude Graph
Number 1353

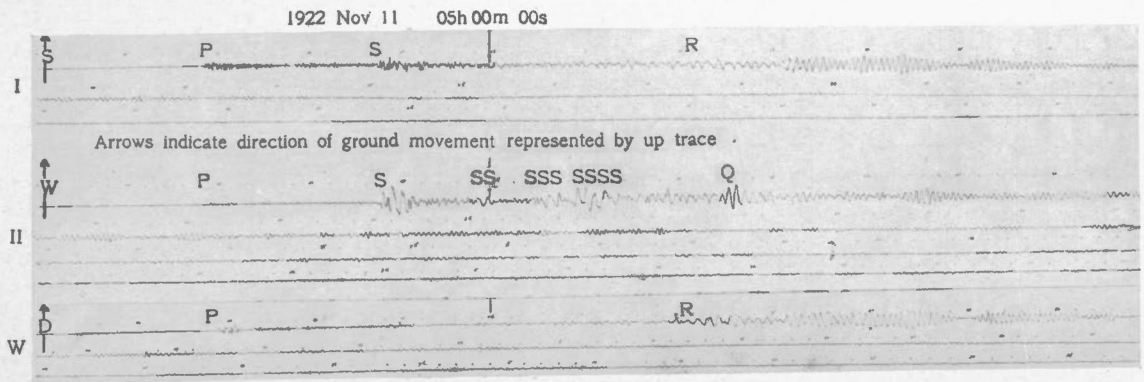


FIGURE 18c
Tracings of Original Seismograms
Number 1353

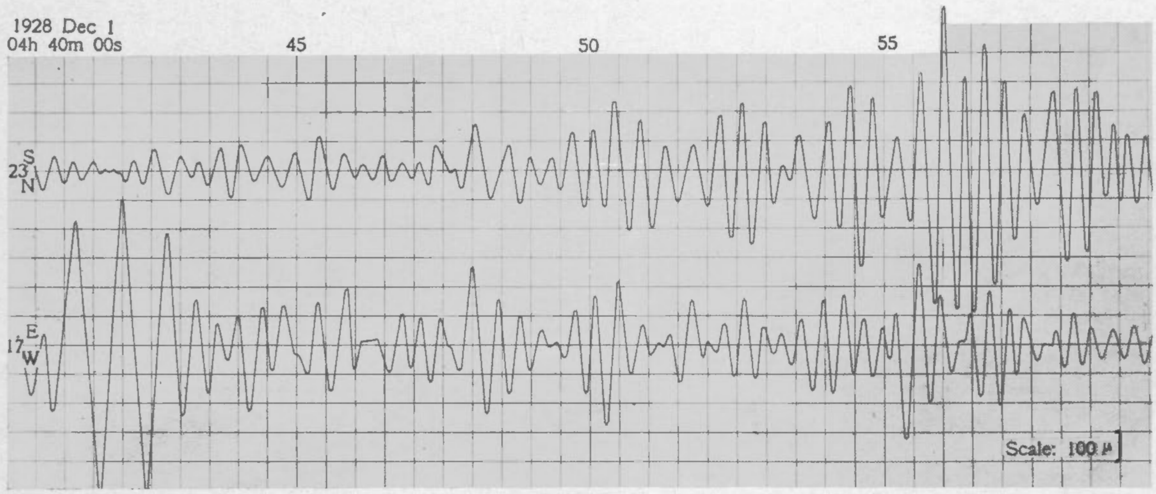


FIGURE 19
Earth Amplitude Graph
Number 3314

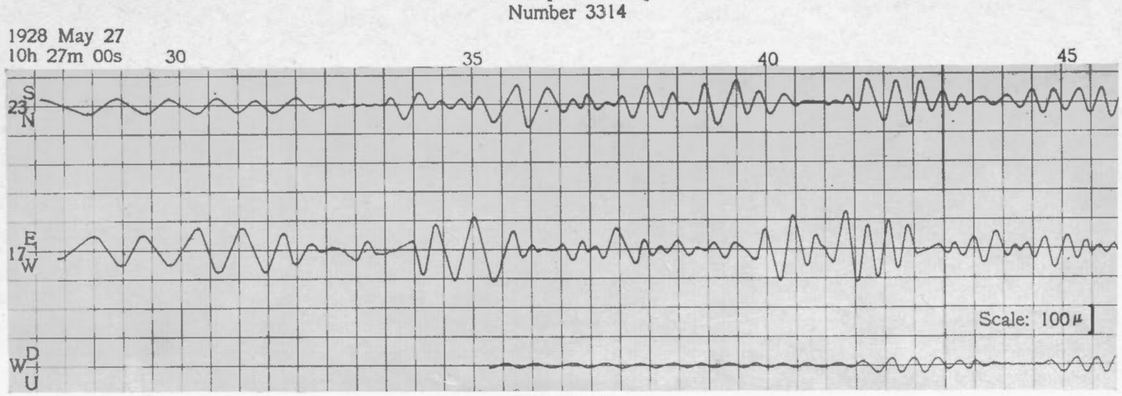


FIGURE 20
Earth Amplitude Graph
Number 3161

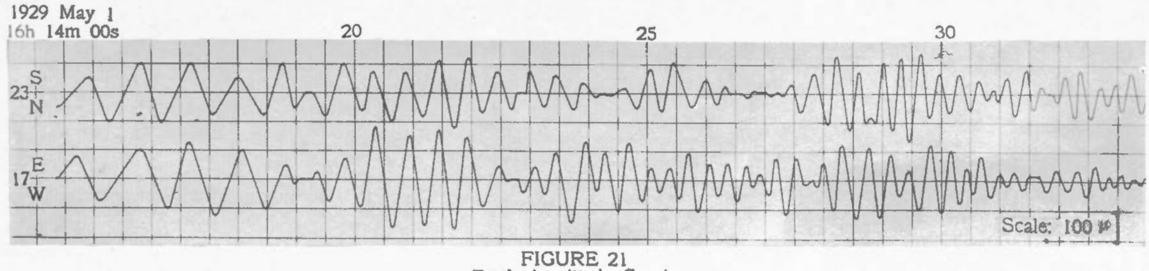


FIGURE 21
Earth Amplitude Graph
Number 3437

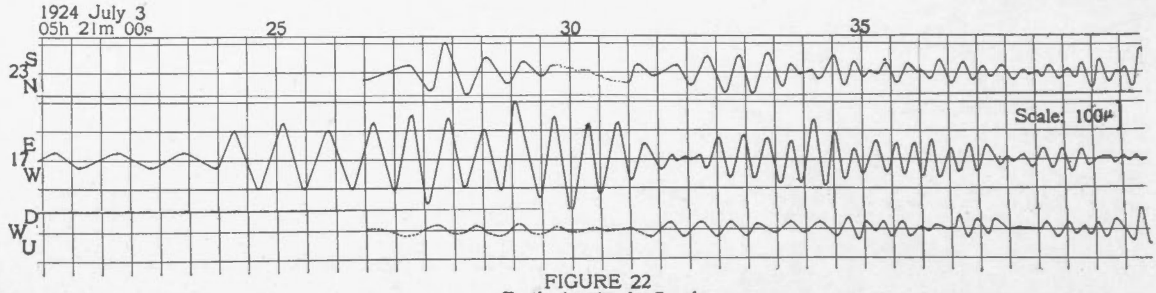


FIGURE 22
Earth Amplitude Graph
Number 1815

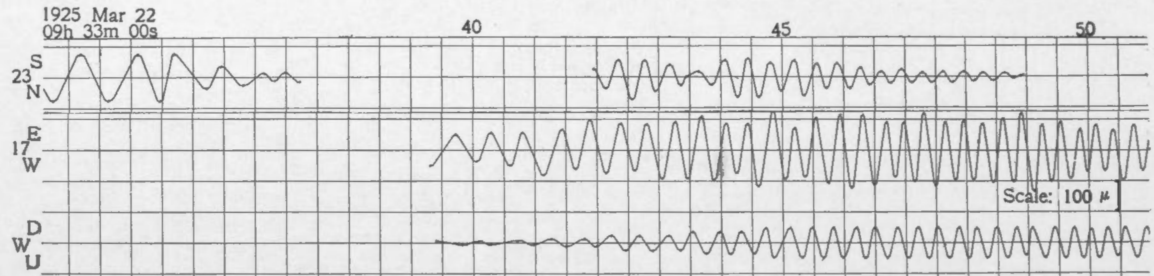


FIGURE 23
Earth Amplitude Graph
Number 2028

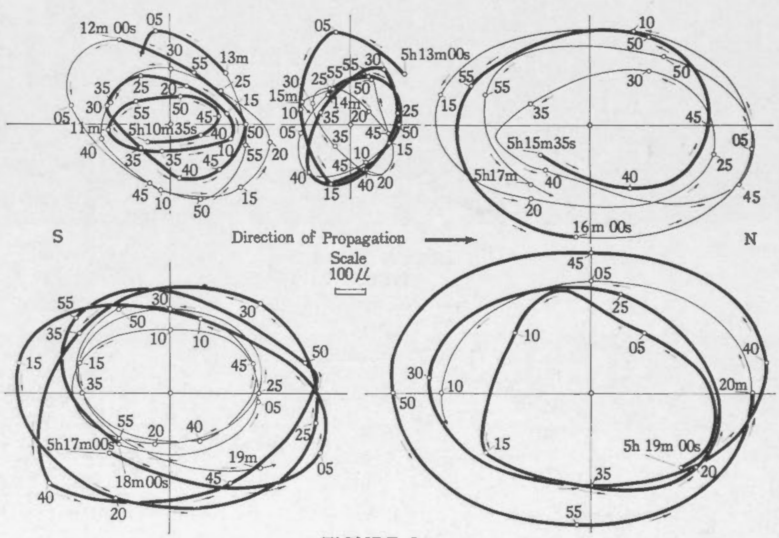


FIGURE 24
Earth Particle Paths
Number 1353

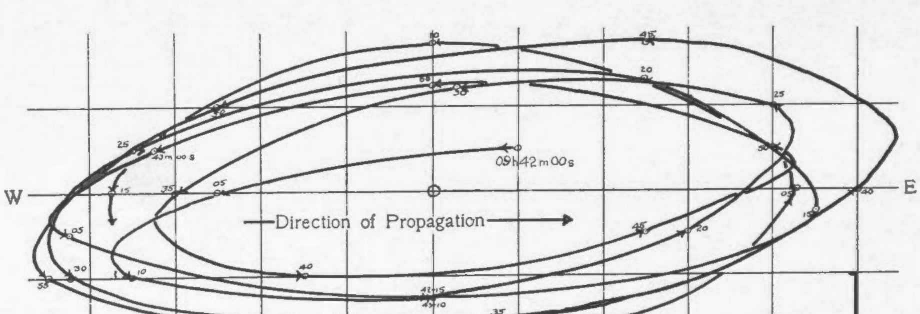


FIGURE 25
Earth Particle Path
Number 2028

PUBLICATIONS OF THE DOMINION OBSERVATORY

VOL. 7 NO. 7 1948

The Grand Banks Earthquake of November 18, 1929

BY

W. W. DOXSEE

ABSTRACT

The area over which the tremors were felt is outlined, as based on replies to questionnaires and collected newspaper reports. Reported damage from the resultant tidal waves which affected the southeastern shores of Newfoundland and some parts of Cape Breton is summarized. Four transatlantic cable companies suffered extensive loss due to a multiplicity of breaks in their lines crossing or approaching the disturbed zone of ocean floor. These are listed, giving the geographical coordinates of the point or points of breakage and the times at which the services were interrupted. Seismographic stations, representing a world-wide distribution of recording points, supplied seismograms, from the interpretation of which, data were obtained for the time of occurrence of the disturbance at its origin and also its epicentre as determined by the stereographic projection method. All the evidence at hand seems to indicate a subsidence of a section of the ocean floor between two fault planes with the vertical displacement progressively less toward the southern extremity of the disturbed zone.

The Grand Banks Earthquake of November 18, 1929, was comparable in intensity with that of the St. Lawrence shock of March 1, 1925, and considerably greater than that which caused so much damage at Santa Barbara on June 29, 1925. The origin was just beyond the continental shelf at approximately 44·5° N. latitude and 55·0° W. longitude and the time of occurrence $20^h31^m53^s$ Greenwich Mean Time. The tremors were felt throughout Newfoundland, the Maritime Provinces, Eastern Quebec, and the northern New England States. Records were obtained at practically all seismographic stations in operation at the time of the disturbance. The damage to land structures due directly to the earth tremors was of but a minor nature but telegraphic cable services were seriously affected, twelve of the transatlantic lines being broken. The resulting tidal wave took a toll of over a score of lives and caused considerable damage to shipping and to shore structures along the southeastern portion of Newfoundland and some seaboard sections of Cape Breton. The earthquake is outstanding in that this locality has been regarded as unusually free of major seismic activity.

ISOSEISMALS

Canadian field data were collected through the medium of newspaper clippings and a questionnaire service covering Newfoundland, Nova Scotia, New Brunswick, Prince Edward Island, Quebec, and the eastern half of Ontario. A similar survey of the New England States of Maine, New Hampshire, Vermont, Massachusetts, Rhode Island, Connecticut, New York, and Delaware was conducted by the United States Coast and Geodetic Survey whose cooperation in this and also in other phases of the investigation is gratefully acknowledged. The combined canvass secured reports from 331 localities. With the exception of northern Quebec Province this brought returns from districts well distributed throughout the States and provinces named. The tremors were reported as

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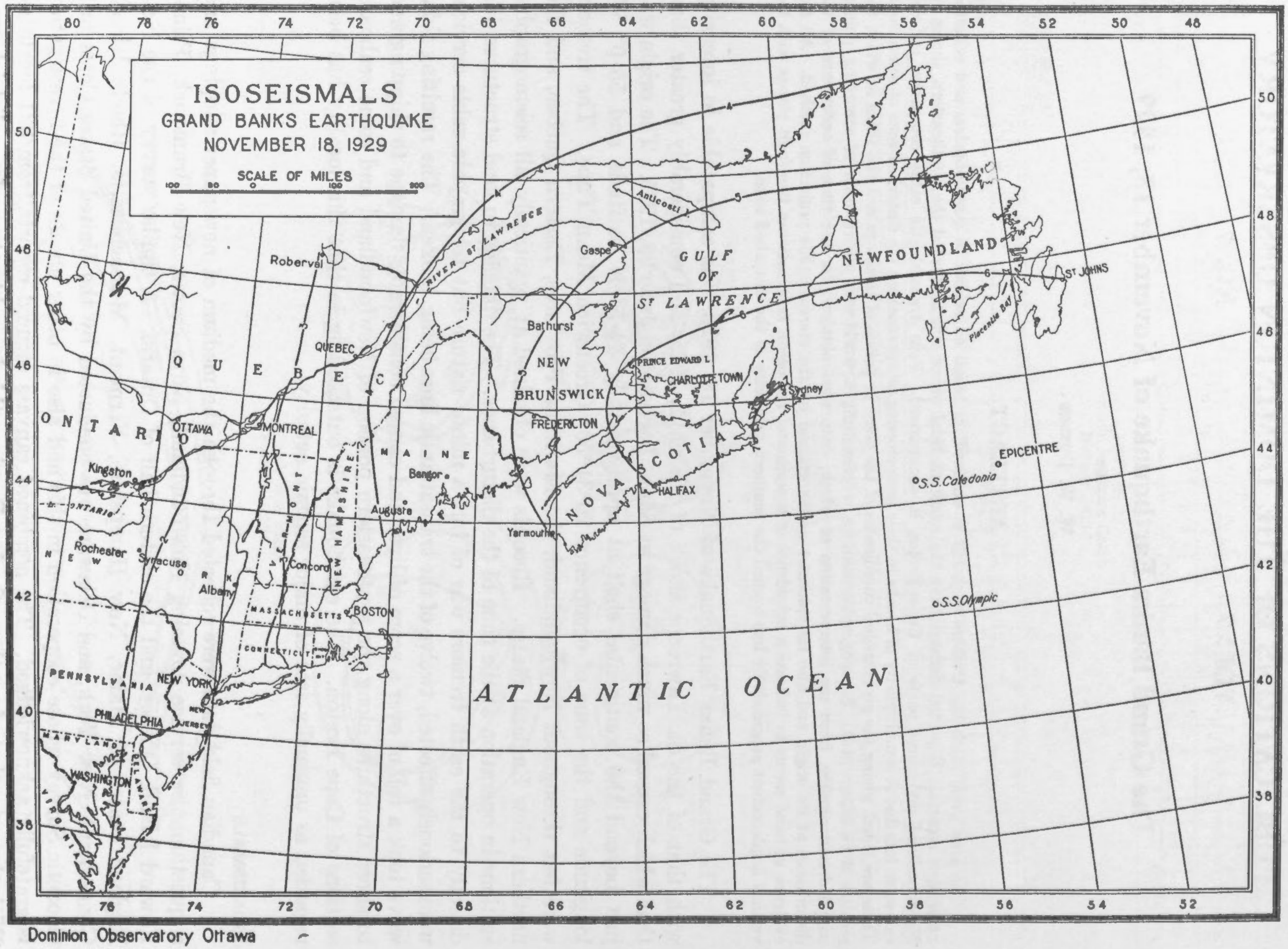


Isoseismal Map. Figure 1.

perceptible as far west as Ottawa, Ontario, and south to Claymont in the State of Delaware. With but very few exceptions the evidence of moving objects and accompanying sounds was found to be consistent, pointing to an epicentre south of Newfoundland, east of Quebec and the Maritimes, and north or northeast of the New England States. All reports received were classified according to the Rossi-Forel scale of intensities and the ratings thus obtained were used to draft the isoseismal map given in Figure 1. The submarine origin precluded the plotting of closed contours which would have served to determine the epicentre approximately. The map can, therefore, serve only to indicate the extent of land surface affected and the degree of severity of the shock within that area. The continental zone within which appreciable damage occurred was comparatively small, being restricted practically to Cape Breton Island. Within this area chimneys were overthrown or cracked, loose objects and stores dislodged from shelves and cupboards, and some highways blocked as the result of minor landslides. An early report that the railway bridge at Grand Narrows had been damaged proved erroneous as also did that regarding a fall at the mines in the Glace Bay district. Two ships at sea, the Caledonia and the Olympic, reported the tremors as severe and of about two minutes duration. The respective positions of these ships at the time of the earthquake are indicated on the isoseismal map as is also the epicentre as located from instrumental records.

TSUNAMI (TIDAL WAVE)

High tide was predicted and expected on the day on which the earthquake occurred: the fact that many places along the seaboard reported exceptionally high tides was probably as much due to the heavy gale at sea as to the tsunami which followed the earth shock. Damage resulting from the tidal wave was reported from some sections of Nova Scotia but principally from southeastern Newfoundland. Sweeping in from the Atlantic, it struck with greatest force on the west side of Placentia Bay at the lower end of Burin peninsula, taking a toll of twenty-seven lives and causing enormous loss of property. The following is the summary given in the Saint John's Free Press in the issue of November 26, 1929.

Lamaline

One man died of injuries. All stages and stores along the waterfront were swept away.

Point au Gaul

Eight lives lost; all fishing property, stages, stores, five cod traps, all provisions, about one hundred tons of coal, three dwelling houses, and seventy other buildings gone.

Taylor's Bay

Four lives lost and fifteen families homeless, all fishing property with provisions and coal swept away.

Lord's Cove

Four lives lost, all fishing property with provisions and coal swept away.

Lawn

No lives lost, all fishing properties with most of the boats, dories, provisions, and coal lost.

St. Lawrence

No lives lost, all flakes and stores on both sides of the harbour swept away with all provisions and coal.

Corbin

Swept clean, no lives lost.

Lance au Lean

One dwelling house and all fishing gear lost.

Great Burin

Swept but no lives lost.

Step-a-side

All waterside premises gone. No loss of life.

Kelly's Cove, Ship Cove, Burin North and Burin East

All waterside premises lost or damaged. No lives lost.

Port au Bras

Eight lives lost, eleven dwelling houses, fourteen small schooners, all dories and skiffs, provisions, and all waterside premises gone.

Mortur

No loss of life. Considerable damage to waterside premises.

Rock Harbour

Reported swept.

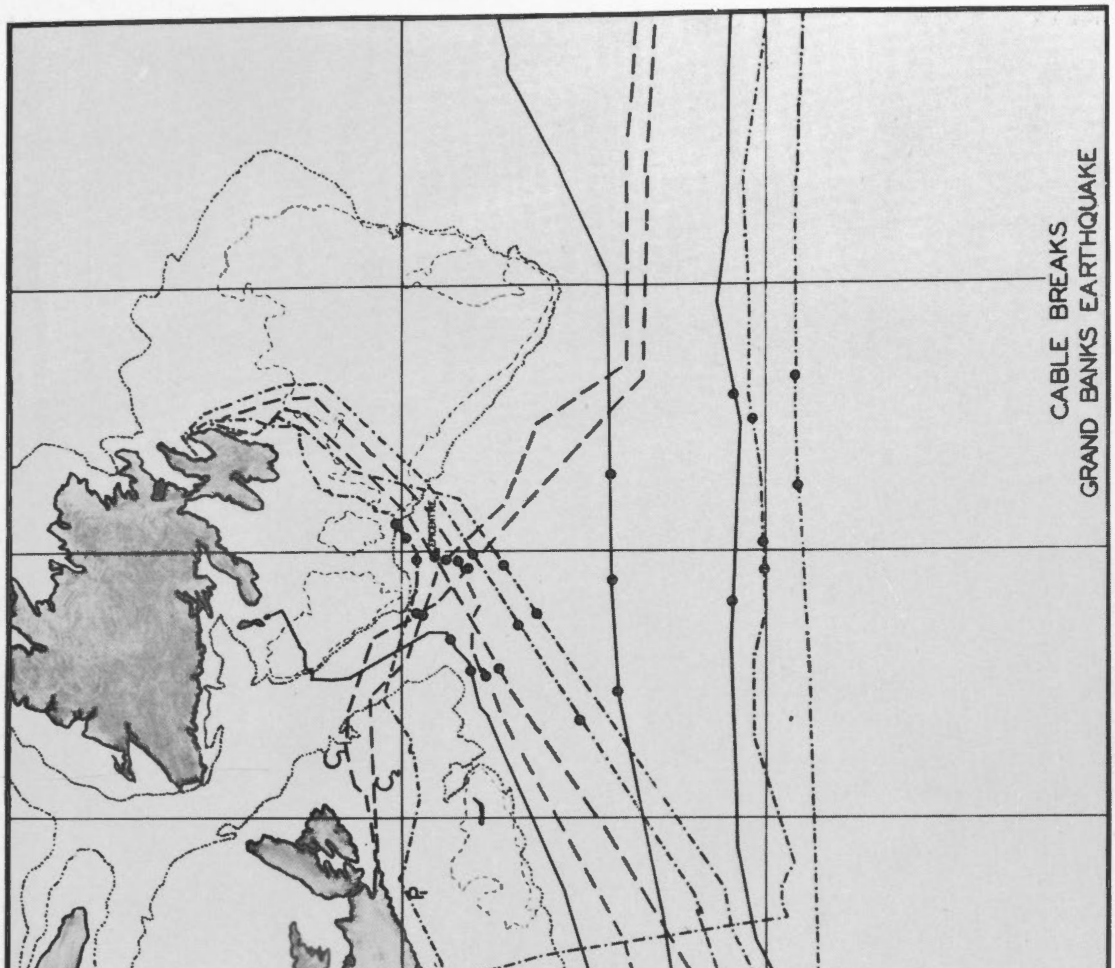
The French islands of St. Pierre and Miquelon escaped damage as did the western coast of the peninsula. To the east at Salmonier at the head of St. Mary's Bay the wave was reported as a six-foot wall of water which caused considerable damage to floating timber.

At Sydney and Glace Bay in Cape Breton and at Halifax Harbour abnormally high tides were reported, but no damage other than flooding was indicated. At Boston the tide was reported as considerably higher than normal with some flooding in a northern suburb. At Canso, Nova Scotia, a tidal wave about two feet in excess of Spring High tide was noticed at about 8 p.m. Atlantic Standard Time on November 18. The wave came in with great force damaging fishermen's wharves and carried ashore the schooner *Lena M* which was badly damaged and her cargo of produce a total loss.

A report* in the *Bermuda Gazette* and *Colonial Daily* states that on the evening of the earthquake a dredging plant at the Flatts was violently disturbed by what was thought to be a tidal wave. So great was the force of the disturbance that the mooring chains were broken and the dredger 70 feet long and 25 feet in depth was in danger of being dashed against the wharf. The time reported was 7.30 p.m. local time.

An article in the Montreal *Herald* of January 2, 1930, states that the wave was noted at 4.30 o'clock at the Azores on the morning following the earthquake.

* Brought to our attention through the kindness of Dr. R. A. Daly of Harvard University.



Map of Cable Breaks. Figure 2.

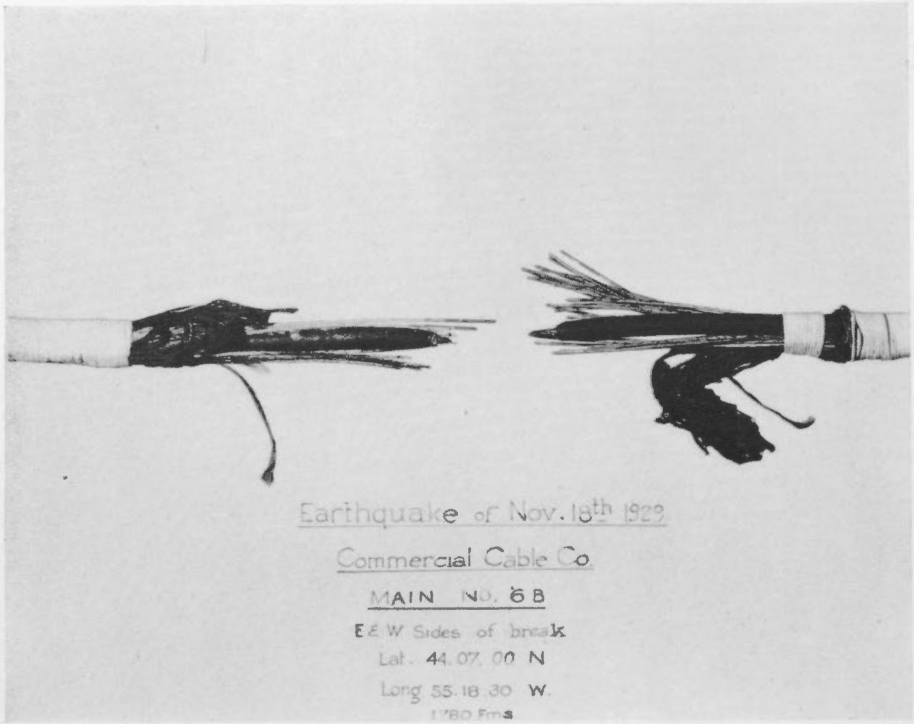


Figure 3.

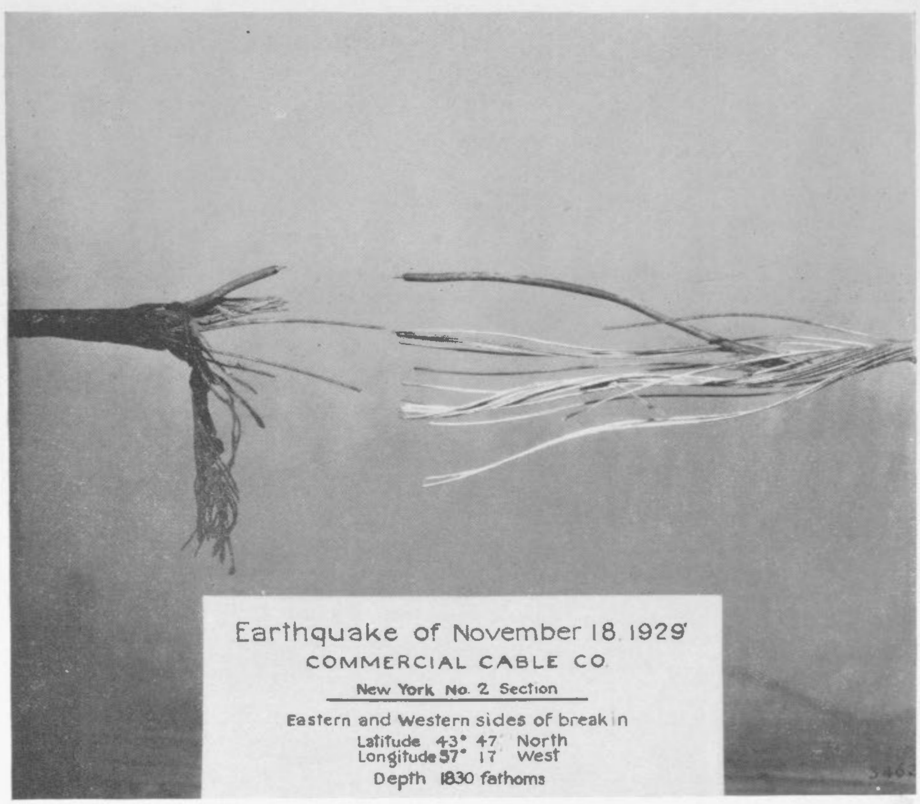


Figure 4.

The Bermuda report would indicate a travel speed of about 350 miles per hour while the Azores time of arrival would give a speed of approximately 250 miles per hour in the north Atlantic water. The arrival time at Burin is given as 7.15 p.m. local time which would indicate a velocity of only about 65 miles per hour, the lower rate of propagation for shallow water being confirmed by the Canso report which placed the time at approximately 8 p.m. which gives a wave velocity of about 80 miles per hour.

The Canadian Hydrographic Service of the Department of Marine supplied copies of tide gauge records as obtained at Halifax, Charlottetown, Saint John, N.B., Gaspe and Quebec. A study of these indicates that the disturbance at sea was not unusual except in the case of Halifax where tide surges were recorded at 7.30 p.m. and again at midnight, Atlantic Standard Time, on November 18.

The collected data indicate that the tidal wave of itself was not of major proportions, its effect being intensified by an exceptionally high tide and a high gale blowing in from the sea. Damage occurred only at places located at the heads of converging bays bounded by rocky walls.

Cable Breaks

No official statement has been obtained as to the monetary loss resulting from the twenty-eight cable breaks caused by the earthquake of November 18, 1929, but many miles of new cable were required to effect the repairs which in come cases were not completed until late in the summer of 1930. Of the twelve transatlantic cables damaged by the shock, three were the property of the Western Union Cable Company, three of the French Cable Company, four of the Commercial Cable Company and two of the Imperial Cable Company. These are shown in Figure 2, a composite map of cable breaks, on which Western Union breaks are indicated as W_1, W_2, W_3; French Cable by F_1, F_2, F_3; Commercial Cable by C_1, C_2, C_3, C_4; and Imperial Cable by P_1 and P_2.

The data as supplied by the respective Companies are given in the following summary:

CABLE BREAKS

Break No.	Lat. N.	Long. W.	Time	Date	Depth (fathoms)
Western Union Cable Company					
New York—Bay Roberts (W_1)					
1	43° 37′	55° 15′	4.31 p.m.	18/11/29	2,000
2	43° 15′	56° 07′	4.31 p.m.	18/11/29	2,200
New York—Bay Roberts (W_2)					
3	44° 02′	55° 02′	3.31·5 p.m.	18/11/29	1,800
4	43° 25′	56° 20′	3.32·5 p.m.	18/11/29	2,000
5	42° 42′	58° 10′	?	18/11/29	2,300

CABLE BREAKS—*Continued*

Break No.	Lat. N.	Long. W.	Time	Date	Depth (fathoms)
***Western Union Cable Company—*Concluded**					
New York—Fayal (W_2)					
6	39° 35′	51° 41′	4.53 a.m.	19/11/29	2,800
7	39° 29′	53° 47′	4.49 a.m.	19/11/29	2,780
French Cable Company					
Saint Pierre—Cape Cod (F_1)					
8	44° 20′	56° 40′	3.46 p.m.	18/11/29	1,150
9	44° 03′	57° 12′	?	18/11/29	1,000
Cape Cod—Brest (F_2)					
10	42° 07′	53° 30′	?	18/11/29	2,600
11	42° 05′	55° 30′	6.35 p.m.	18/11/29	2,400
12	42° 00′	57° 36′	?	18/11/29	2,500
New York—Fayal (F_3)					
13	40° 28′	52° 06′	12.33 a.m.	19/11/29	2,800
14	40° 30′	55° 55′	12.33 a.m.	19/11/29	3,000
Commercial Cable Company					
Canso—Fayal (C_1)					
15	44° 07′	55° 18′	3.33 p.m.	18/11/29	1,780
16	44° 45′	56° 09′	3.33 p.m.	18/11/29	310
Canso—Fayal (C_2)					
17	44° 23′	55° 08′	3.33 p.m.	18/11/29	1,500
18	44° 43′	56° 10′	3.33 p.m.	18/11/29	220

CABLE BREAKS—*Concluded*

Break No.	Lat. N.	Long. W.	Time	Date	Depth (fathoms)
Commercial Cable Company (Continued)					
N.Y. 2 New York—Saint Johns (C_3)					
19	44° 12′	55° 10′	3.33 p.m.	18/11/29	1,820
20	43° 47′	57° 17′	3.33 p.m.	18/11/29	1,830
N.Y. 1 New York—Saint Johns (C_4)					
21	44° 32′	55° 04′	3.33 p.m.	18/11/29	1,450
22	43° 41′	57° 07′	?	18/11/29	1,890
Imperial Cable Company					
Halifax—Harbor Grace (P_1)					
23	45° 05′	54° 27′	3.33 p.m.	18/11/29	150
24	44° 55′	54° 45′	3.33 p.m.	18/11/29	700
25	44° 50′	55° 09′	3.32 p.m.	18/11/29	800
Halifax—Fayal (P_2)					
26	40° 13′	52° 30′	3.50 a.m.	19/11/29	2,800
27	40° 02′	54° 50′	1.50 a.m.	19/11/29	2,900
28	40° 00′	55° 20′	1.50 a.m.	19/11/29	3,190

The summary shows that each of the twelve lines was broken in at least two places, in the case of four of them there were triple breaks. It also makes evident the fact that the breaks range themselves into two groups whose east and west separation becomes greater as the progression extends southeast from the epicentral zone to about 39° north latitude. This evidence suggests a subsidence of the ocean floor between two fault planes each roughly parallel to the axis of the Cabot trench and extending from about 45° N. to approximately 39° N. The large number of cables grouped near the mouth of the Cabot trench accounts in a large measure for the concentration of breaks in that area. On the other hand, the fact that practically all of these occurred at the same time as the earthquake, while those to the south were later, some as late as 4.53 a.m., E.S.T., November 19, 1929, would indicate that the greatest displacement was in the northern section of the disturbed zone. That this area was violently disturbed is shown by an examination of the recovered cables which evidently had been subjected to a sharp and sudden strain at the point of fracture. The two photographs (Figures 3 and 4) supplied by the Commercial Cable Company indicate that these cables were literally pulled apart.

There is a possibility that the break in the French Cable Company's Cape Cod-Brest line which occurred at 6.35 p.m., E.S.T., November 18, 1929 may have resulted from the pronounced aftershock, the first tremors of which were recorded at the Halifax seismographic station at 6.04 p.m. of that date.

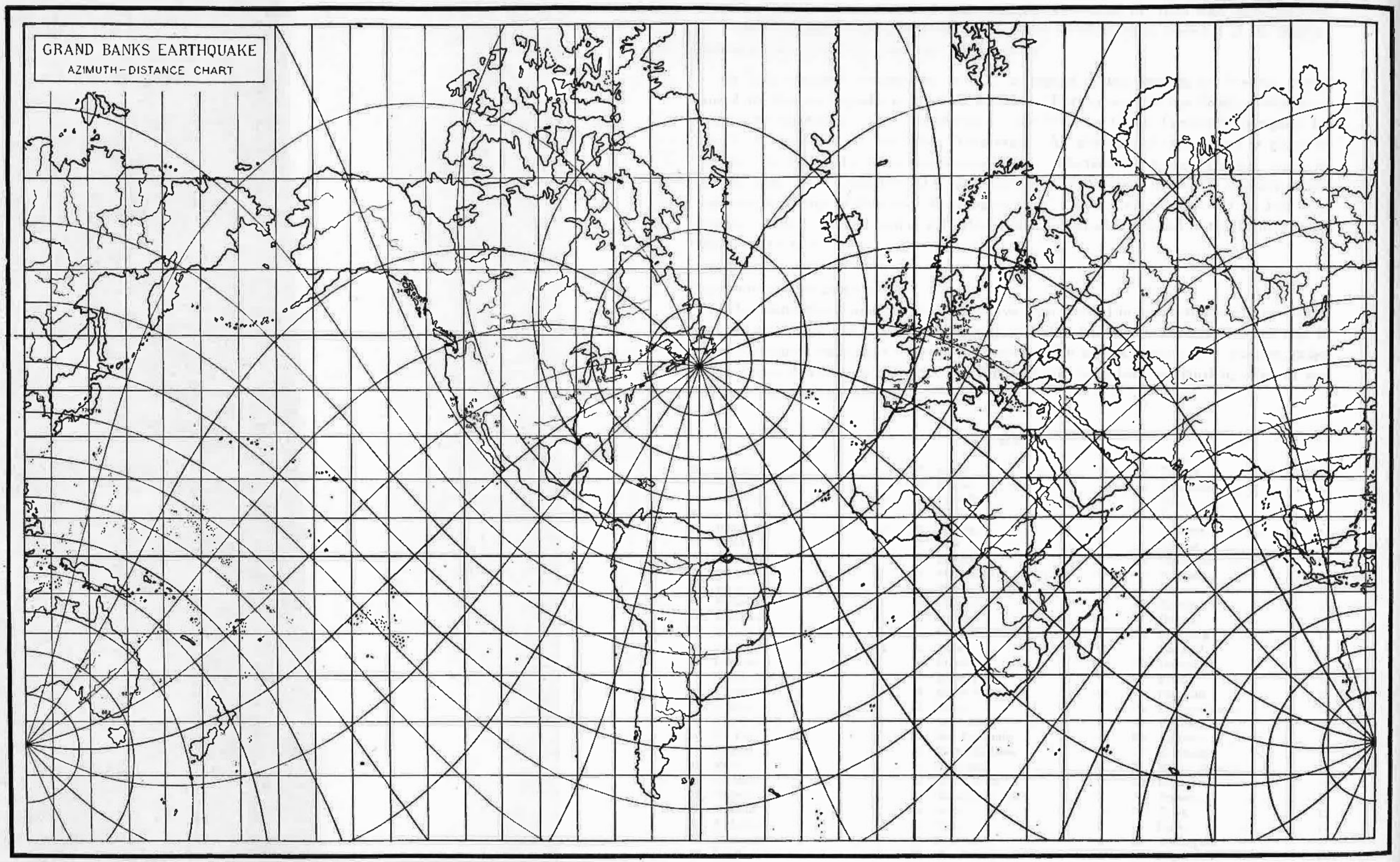
A very complete compilation of data in regard to the damage to Atlantic cables caused by this earthquake is given in a report "Earthquakes in the North Atlantic as Related to Submarine Cables" prepared for the Western Union Telegraph Company by Mr. V. P. de Smitt of their New York staff. An abstract of this report is given in *Transactions of the American Geophysical Union*, Thirteenth Annual Meeting, April 28 and 29, 1932, at Washington, D.C. published by the National Research Council of the National Academy of Sciences, Washington, D.C., June, 1932, pages 103 to 109 with 5 figures. Other papers dealing with this submarine shock are listed in the Bibliography following the text.

Seismogram Interpretations

The seismograms and reports which have been studied in connection with the Grand Banks Earthquake are listed alphabetically in Table 1 in which the letters O, C, and R indicate original, copy, and report respectively. The numbers serve as a position index to the Azimuth-Distance map given in Figure 5 and have been assigned in order of the relative epicentral distances.

TABLE 1

38	Abisko	O	72	Ksara	O	32	Taunus	O
41	Algiers	O	66	Kucino	R	49	Tinemaha	O
10	Ann Arbor	O	60	La Jolla	O	77	Tokyo	C
83	Apia	O	67	La Paz	C	20	Toledo	O
27	Balboa	O	39	Leipzig	O	7	Toronto	O
73	Baku	R	51	Lick	O	25	Tortosa	C
30	Barcelona	C	84	Manila	C	13	Florissant	O
85	Batavia	C	88	Melbourne	C	5	Fordham	O
64	Beograd	O	58	Mount Wilson	O	50	Graz	C
62	Berkeley	O	43	München	O	48	Haiwee	O
29	Besancon	O	6	Ottawa	O	1	Halifax	O
61	Budapest	O	17	Oxford	C	35	Hamburg	O
8	Buffalo	O	22	Paris	O	3	Harvard	O
26	Cartuja	C	55	Pasadena	O	31	Heidelberg	O
9	Charlottesville	O	87	River View	O	89	Perth	C
11	Chicago	O	56	Rocca di Papa	O	45	Piacenza	O
79	Colaba	C	53	Rome	O	14	Port-au-Prince	O
34	Copenhagen	C	12	Saint Louis	O	47	Potsdam	C
24	De Bilt	O	21	San Fernando	O	63	Pulkovo	C
18	Denver	O	59	Santa Barbara	O	19	Richmond	C
42	Eger	C	15	Saskatoon	O	71	Rio de Janeiro	C
46	Firenze	O	2	Seven Falls	O	52	Riverside	O
28	Helgoland	C	4	Shawinigan Falls	O	40	Tucson	O
70	Helwan	C	54	Sitka	O	76	Tyosi	C
37	Hohenheim	O	65	Sofia	O	23	Uccle	C
74	Honolulu	O	16	Stonyhurst	O	86	Wellington	C
44	Innsbruck	O	36	Strasbourg	O	57	Zagreb	O
75	Jinsen	O	68	Sucre	C	80	Zi-ka-wei	O
78	Kobe	C	69	Sverdlovsk	R	33	Zürich	O
81	Kodaikanal	C	82	Sydney	C			



Azimuth Distance Chart. Figure 5.

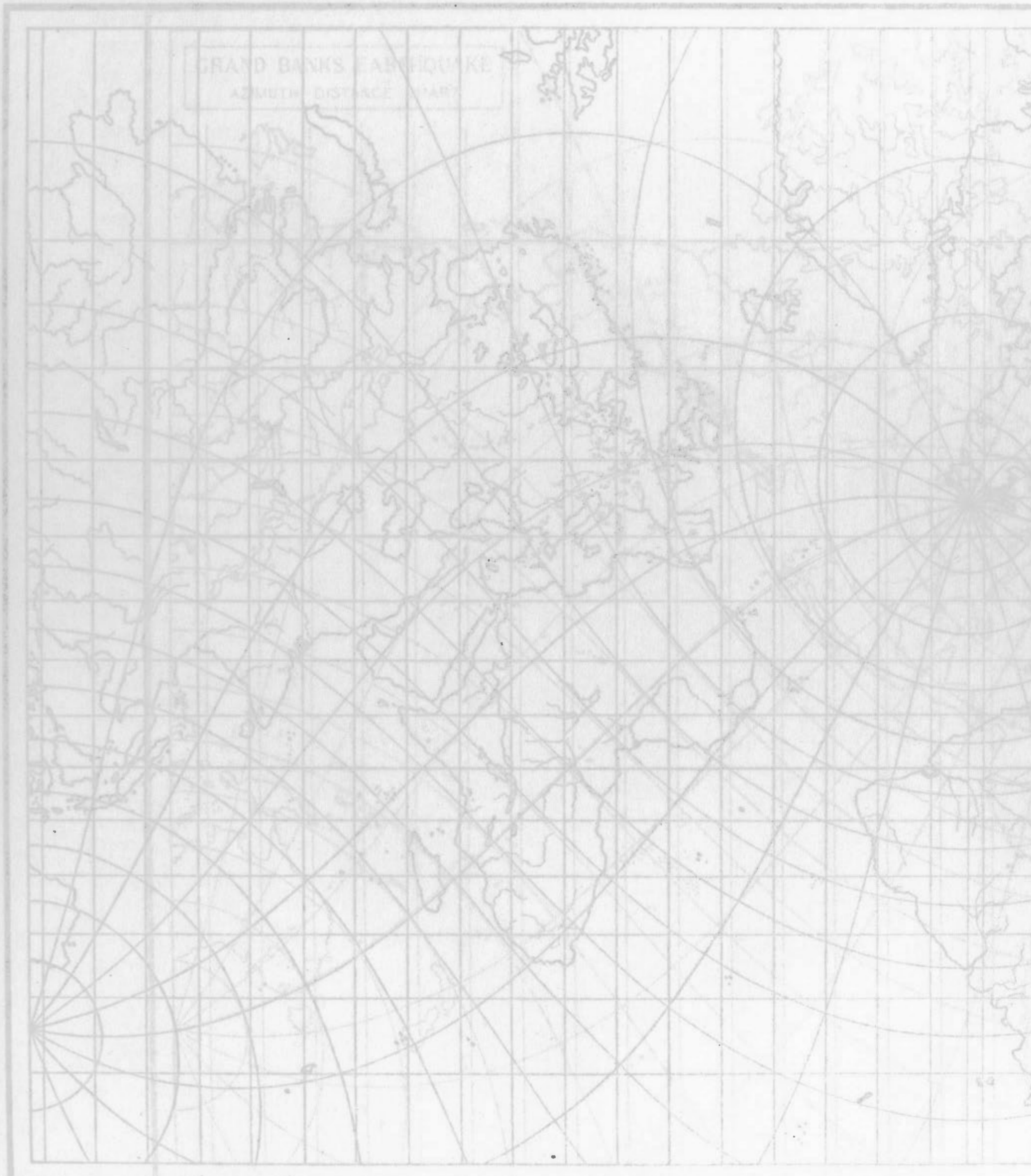


Figure 3.

The Azimuth Distance Chart shows the world-wide distribution of the eighty-nine stations listed in the above table. In all, two hundred and eleven component records were received for interpretation, the identification of the various phases being based on the travel times given in the Macelwane Tables. Some of the seismograms were incomplete but in the case of sixty-six of these stations, records were obtained on which the time of arrival of the compressional waves (P) and the shear waves (S) were definitely identified. For each of these stations the S-P time interval was used to determine the epicentral distance (△) and the Greenwich Mean Time (H) of the disturbance at its origin. These data are presented in summary form in Table II retaining the same station index numbers as were given in Table I.

TABLE II

	Station	P	S	H	△ (km.)
2	Seven Falls	$20^h34^m26^s$	$20^h36^m24^s$	$20^h31^m57^s$	1133
3	Harvard	20 34 32	20 36 40	20 31 51	1233
4	Shawinigan Falls	20 34 45	20 36 54	20 32 02	1244
5	Fordham	20 35 09	20 37 28	20 32 14	1344
6	Ottawa	20 35 13	20 37 43	20 32 06	1444
7	Toronto	20 35 52	20 38 55	20 32 04	1789
8	Buffalo	20 35 52	20 39 05	20 31 51	1900
9	Charlottesville	20 36 07	20 39 26	20 31 57	1978
10	Ann Arbor	20 36 34	20 40 19	20 31 47	2311
11	Chicago	20 37 04	20 41 17	20 31 34	2722
12	St. Louis	20 37 34	20 41 51	20 31 59	2778
15	Saskatoon	20 38 44	20 44 07	20 31 40	3800
16	Stonyhurst	20 38 57	20 44 29	20 31 43	3944
17	Oxford	20 39 10	20 44 45	20 31 53	3978
18	Denver	20 39 34	20 45 10	20 32 15	4000
19	Richmond	20 39 11	20 44 53	20 31 46	4089
20	Toledo	20 39 21	20 45 04	20 31 54	4111
21	San Fernando	20 39 21	20 45 10	20 31 46	4222
22	Paris	20 39 33	20 45 26	20 31 53	4278
23	Uccle	20 39 37	20 45 36	20 31 51	4378
24	De Bilt	20 39 39	20 45 43	20 31 47	4467
25	Tortosa	20 39 47	20 45 51	20 31 55	4467
26	Cartuja	20 39 36	20 45 41	20 31 43	4478
27	Balboa	20 40 06	20 46 16	20 32 08	4556
28	Helgoland	20 40 05	20 46 17	20 32 04	4589
29	Besancon	20 39 56	20 46 10	20 31 53	4622
31	Heidelberg	20 40 13	20 46 28	20 32 09	4644
32	Taunus	20 39 51	20 46 11	20 31 41	4722
33	Zürich	20 40 05	20 46 27	20 31 53	4756
34	Copenhagen	20 40 04	20 46 27	20 31 51	4778
35	Hamburg	20 39 57	20 46 20	20 31 44	4778
36	Strasbourg	20 39 59	20 46 23	20 31 45	4789
37	Hohenheim	20 40 05	20 46 31	20 31 50	4800
38	Abisko	20 40 09	20 46 38	20 31 48	4889
39	Leipzig	20 40 17	20 46 48	20 31 55	4911
40	Tucson	20 40 08	20 46 40	20 31 45	4922
41	Algiers	20 40 12	20 46 46	20 31 46	4967
42	Eger	20 40 18	20 46 55	20 31 48	5022
43	München	20 40 20	20 46 58	20 31 50	5033

TABLE II—*Concluded*

Station	P	S	H	△ (km.)
44 Innsbruck	20h40m23s	20h47m02s	20h31m52s	5044
45 Piacenza	20 40 24	20 47 03	20 31 52	5056
46 Firenze	20 40 30	20 47 13	20 31 55	5111
48 Haiwee	20 40 32	20 47 23	20 31 47	5256
49 Tinemaha	20 40 30	20 47 22	20 31 44	5278
50 Graz	20 40 36	20 47 31	20 31 46	5333
52 Riverside	20 40 36	20 47 35	20 31 41	5411
53 Rome	20 40 45	20 47 44	20 31 50	5411
55 Pasadena	20 40 40	20 47 40	20 31 45	5422
56 Rocca di Papa	20 40 45	20 47 45	20 31 50	5422
57 Zagreb	20 40 50	20 47 50	20 31 55	5422
58 Mount Wilson	20 40 39	20 47 40	20 31 42	5444
59 Santa Barbara	20 40 46	20 47 50	20 31 47	5489
61 Budapest	20 40 56	20 48 05	20 31 51	5578
62 Berkeley	20 41 02	20 48 12	20 31 55	5600
63 Pulkovo	20 41 05	20 48 18	20 31 56	5644
64 Beograd	20 41 11	20 48 31	20 31 53	5778
65 Sofia	20 41 50	20 49 34	20 32 09	6178
66 Kucino	20 41 45	20 49 35	20 31 56	6300
67 La Paz	20 42 18	20 50 38	20 32 01	6800
68 Sucre	20 42 31	20 51 04	20 32 02	7011
69 Sverdlovsk	20 42 45	20 51 31	20 32 04	7244
70 Helwan	20 43 00	20 51 53	20 32 13	7356
71 Rio de Janeiro	20 43 00	20 52 00	20 32 07	7467
72 Ksara	20 43 01	20 52 06	20 32 03	7556
73 Baku	20 43 29	20 52 53	20 32 13	7900
74 Honolulu	20 44 27	20 54 27	20 32 09	9100

The arrangement of the above table shows, to a marked degree, the regular progression of arrival times of the P and S phases with increasing arcual distance. These sixty-six △ values were used to locate the position of the epicentre which was determined by means of the stereographic projection method. The point of intersection of the distance circles places the epicentre at approximately 44·5° N. and 55·0° W. which may be regarded as the section of greatest displacement within the disturbed zone. The time of the disturbance at the origin may be taken as the mean of the tabulated values which gives for H $20^h\ 31^m\ 53^s$ G.M.T. Secondary displacements resulted in at least two aftershocks, the first at approximately $23^h\ 02{\cdot}0^m$ G.M.T. on November 18 and the second at about $2^h\ 01{\cdot}5^m$ G.M.T. on the day following. The first of these was of the greater intensity and was recorded at Halifax, Seven Falls, Shawinigan Falls, Ottawa, Toronto, Fordham, Chicago, St. Louis, Tucson, Tinemaha, Copenhagen, and La Paz. The second shock had the same epicentral distance from the Shawinigan Falls and Seven Falls stations as the first and was recorded also at Halifax, Fordham, St. Louis, Ottawa, and Toronto stations.

The San Francisco earthquake of 1906 was the result of a horizontal displacement whose maximum did not exceed twenty-one feet. Several other major earthquakes have resulted from land movements much less than that which occurred at San Francisco. It is reasonable, therefore, to suppose that in the case of the Grand Banks earthquake the greatest vertical displacement was not in excess of the San Francisco maximum and that at the southern extremity of the disturbed zone the subsidence was in all probability very much less. Such a movement, however, would be sufficient to cause the severance of cable lines between two fault planes and would also account for the successively later times of breakage with increase of distance from the mouth of the Cabot trench. Displacements of the extent mentioned could hardly be detected by soundings taken in the deep waters of the Strait and such discrepancies as appear between old chartings and the soundings taken by the survey, made subsequent to this shock, are probably due to the inaccuracy of the former and also to the more intensive scope as well as the improved methods used for the latter.

The writer wishes to express his appreciation of the co-operation extended by the Directors of the various seismic stations for the loan of records; the Director of the United States Coast and Geodetic Survey for the use of field notes covering the New England States; cable company officials for detailed data regarding cable breaks; newspaper editors for press reports; and the many postmasters and individuals who responded to our questionnaire service.

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resulted from land movements much less than that which occurred in the San Francisco. It is reasonable, therefore, to suppose that in the case of the Grand Banks earthquake the greatest vertical displacement was not in excess of the San Francisco maximum and that at the southern extremity of the disturbed zone the slump, as was in all probability very much less. Such a movement, however, would be sufficient to cause the breaking of cable lines between terminal pieces and would also account for the successively later times of breaking with increase of distance from the mouth of the Cabot Strait. Displacements of the order of one [illegible] might hardly be detected by soundings taken in the deep waters of the slope and what discrepancies do appear between old soundings and the soundings taken by the cable repair ships subsequent to this shock are probably due to the improvements in the sounding technique, to the more intensive soundings as well as the improved methods used by the latter.

The writer wishes to express his appreciation of the co-operation extended by the Officials of the various cable companies for the loan of records; the Director of the United States Coast and Geodetic Survey for the use of [illegible] notes covering the New England States; to the various officials for [illegible] data regarding cable breaks; numerous editors for press reports and the many postmasters and individuals who responded so generously with reports.

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PUBLICATIONS OF THE DOMINION OBSERVATORY

VOL. VII NO. 8 1948

The Earthquake in Montmorency County, Quebec, on January 1, 1948

BY

W. G. MILNE

ABSTRACT

This earthquake is, to date, the most severe of a series of small shocks which have occurred in the Province of Quebec over the past few months. Seismograms from six Canadian stations and from Boston are analysed and the epicentre of the earthquake is computed from the readings. The epicentre so found is about fifteen kilometres north and west of the Seven Falls station in Montmorency County. The position of this epicentre in relation to the location of previous earthquakes is discussed and the possibility of a more accurate determination of the origin of future shocks is proposed.

Introduction

There has been a marked increase in seismic activity in the Province of Quebec over the past few months. This increase has been both in the number and the intensity of earthquakes recorded on the seismographs operated by the Dominion Observatory. Although it cannot be said that this activity is limited to any one region, the majority of the tremors fall within specific areas. The strongest earthquakes appear to come from the St. Lawrence River district below Quebec City, such as the one to be studied in this report.

Seismic Areas of Quebec

The Province of Quebec has been the origin of several severe earthquakes. The most familiar of these earthquakes is that of March 1, 1925. Dr. E. A. Hodgson has placed the epicentre of this shock in the St. Lawrence River near Baie St. Paul. Before this there were several severe earthquakes in that particular area, and since that time there have been fourteen small tremors, both recorded and felt, which have originated near there. In order that all such epicentres might be located seismographs were installed at Seven Falls and Shawinigan Falls. This paper is an attempt to determine the exact position of such a quake which had its origin near the Seven Falls station on January 1, 1948.

In addition to this seismic area, there appears to be quite an active region between the Shawinigan Falls station and Ottawa. This other area, although its tremors are very slight, has much more activity. At present there is a study being made to locate this area, but from the evidence at hand it would appear to be north of Ottawa about one hundred miles. The area north of Ottawa has been shaken on the average of four times a month for the last year. It has been active now for about ten years.

There are, from time to time, very small tremors recorded from places in Quebec not in these two main earthquake belts. However such quakes do not appear to repeat themselves so they can be considered as minor local adjustments of the crustal layers.

Seismograms Studied

In recent years the most severe earthquake was the one at approximately 1:34 p.m., E.S.T. on January 1, 1948. This earthquake had its origin slightly north and west of the Seven Falls seismograph station, about 30 miles down the St. Lawrence River from Quebec City. It was reported as felt in the immediate area. It was well recorded on the seismographs at Seven Falls, Shawinigan Falls, Ottawa, Temiskaming, Ville Marie, and Kirkland Lake. Father Linehan of the Seismological Observatory at Weston College reported his readings to Ottawa, and has since very kindly loaned his records of this quake to the Division for further study.

The Seven Falls Wood-Anderson seismogram showed no phases after the initial P-phase because of its proximity to the epicentre. It did, however, give a very sharp P_1-phase and the corresponding S_1-phase was obtained from the east-west component Milne-Shaw seismogram of the same station. This component showed a sharp S_1-phase; which would indicate an origin in a northerly or southerly direction. In fact the S-phase was so strong that it displaced the zero position of the Milne-Shaw instrument by as much as two millimetres. At Shawinigan Falls, on the north-south Wood-Anderson seismograph, the initial P-phase was not strong, but there was a strong S_1-phase indicating an origin in an easterly or westerly direction. The Ottawa vertical component short-period Benioff seismogram, and the Weston vertical and horizontal Benioffs showed quite definite phases. The Weston three-component Galitzen seismograms were used as well for S-phase confirmations. The stations at Ville Marie and Temiskaming each use three-component Sprengnether seismographs. Unfortunately, at Ville Marie there was no time control for this day. There is a single vertical component Sprengnether seismometer at Kirkland Lake. From all Sprengnether instruments well defined S-phases were obtained, but the P-phase readings are doubtful. All seismograms used in this study have the sixty millimetre paper speed with automatically recorded radio time signals from CHU at Ottawa, so that the time control is excellent. Copies of the seismograms used are shown in figures 1 and 2.

Interpretation of Readings

The following table gives the final readings of the phases from all records. The values of Δ and H are obtained from an S-P computation using Joliat's Tables for Near Earthquakes (Saint Louis, 1931). All times are 18 hours G.C.T. plus the minutes as shown below.

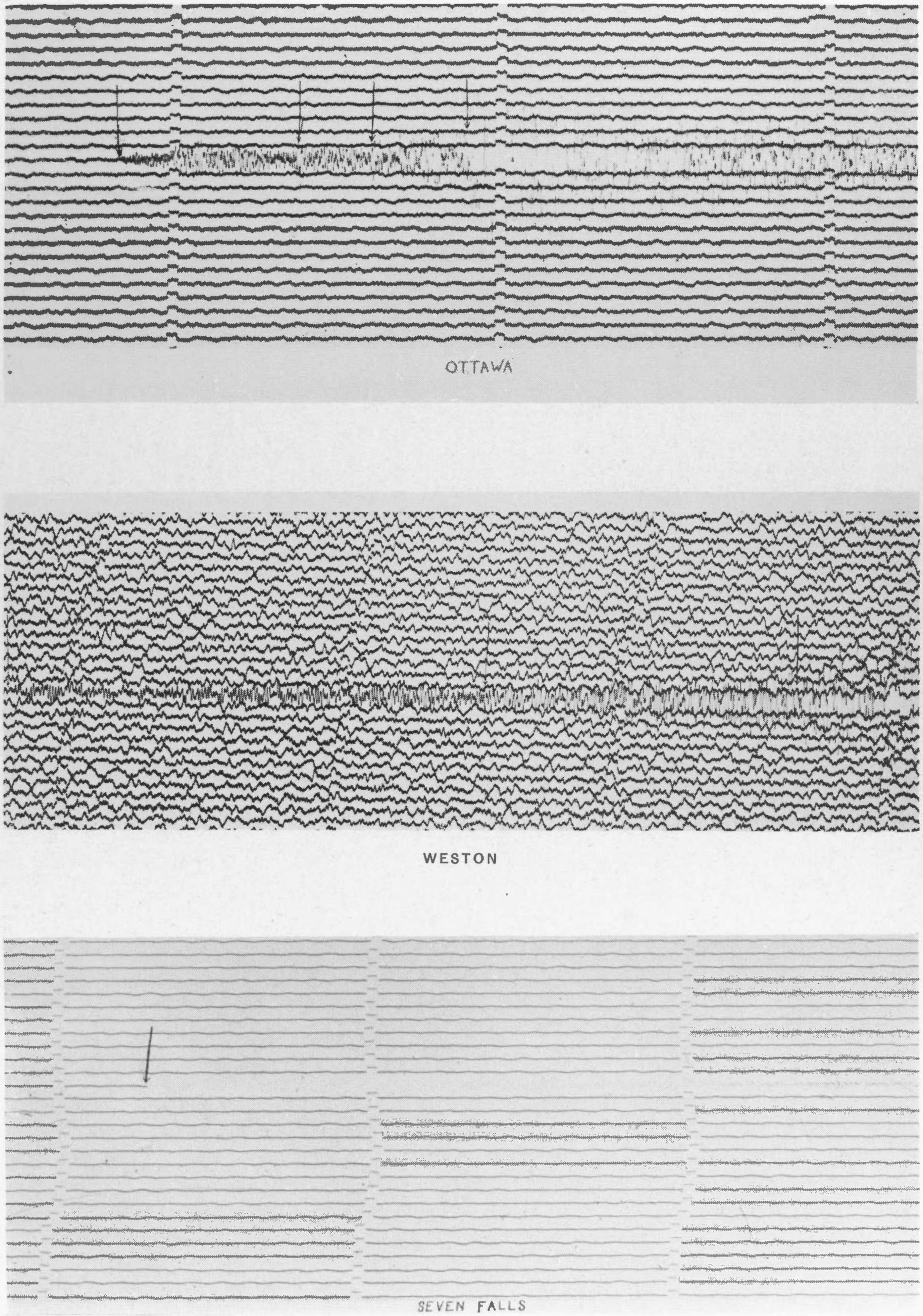


Fig. 1

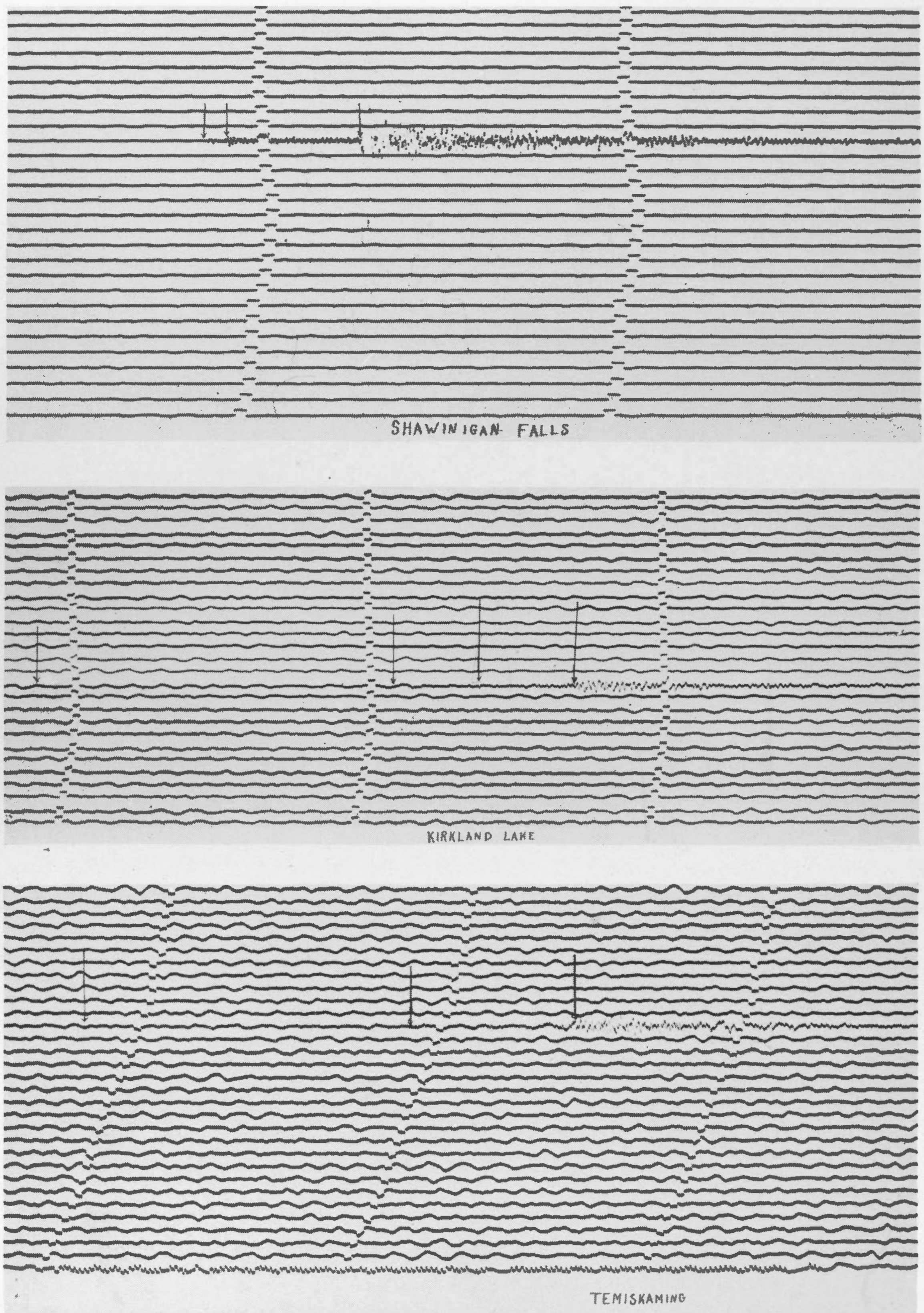
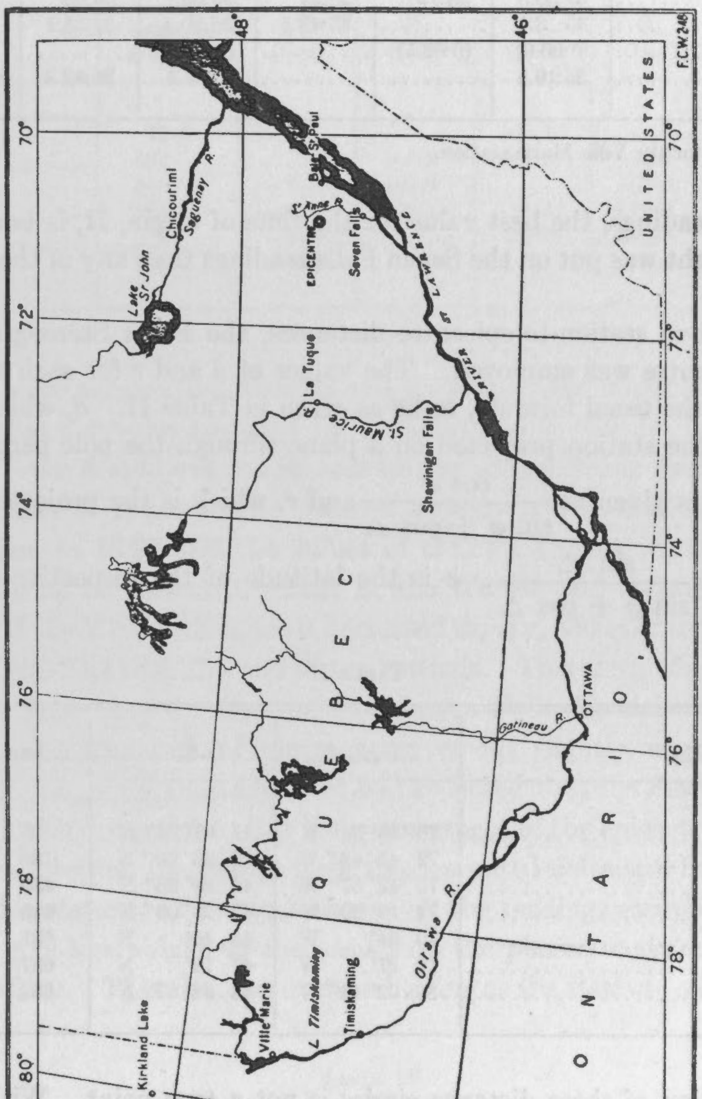


Fig. 2



80°
78°
76°
74°
72°
70°
48°
46°
Kirkland Lake
Ville Marie
L. Timiskaming
Timiskaming
Ottawa R.
Q U E B E C
O N T A R I O
Gatineau R.
OTTAWA
St. Maurice R.
La Tuque
Shawinigan Falls
Lake St. John
Chicoutimi
Saguenay R.
EPICENTRE
St. Anne R.
Baie St. Paul
Seven Falls
RIVER St. LAWRENCE
UNITED STATES
F.C.W.248

Fig. 3

TABLE I

Station	P_n	P_2	P_1	S_n	S_2	S_1	Δ(km.)
Seven Falls	....	....	33:52.9	....	....	33:57.9	25
Shawinigan Falls	....	34:17.3	34:20.6	34:36.8	....	34:42.8	188
Ottawa	34:48.5	34:56	....	35:35	....	35:52.5	430
Weston	34:58.8	35:10	35:21	35:53.8	36:08	36:24	515
Temiskaming	35:13.4	....	35:43.4	36:20.4	36:38.1	36:51.4	631
Ville Marie*	(0:00.0)	(0:03.5)	....	(1:07.5)	....	(1:40.5)	637
Kirkland Lake	35:19.5	....	....	36:30.3	36:32.3	37:08.5	669

*No absolute time for the Ville Marie station.

Using these readings, the best value for the time of origin, H, is taken as 18:33:48.0 G.C.T. More weight was put on the Seven Falls readings than any of the others to obtain this value.

From the above station-to-epicentre distances, the Klotz Stereographic method of obtaining an epicentre was employed. The values of d and r for each station and delta were found, from the usual formula, to be as given in Table II. d, which is the distance from the pole to the station projected on a plane through the pole perpendicular to the axis of the earth, is given as $\dfrac{\cos\varphi}{\sin\varphi + \cos\Delta}$ and r, which is the projected station to epicentre distance, as $\dfrac{\sin\Delta}{\sin\varphi + \cos\Delta}$. φ is the latitude of the respective station.

TABLE II

Station	Longitude	Latitude	Δ(kms.)	d	r
Seven Falls	70 49′ 36″ W	47 07′ 24″ N	25	392·7	2·26
Shawinigan Falls	72 45′ 48″ W	46 33′ 06″ N	188	398·6	17·1
Ottawa	75 42′ 57″ W	45 23′ 38″ N	430	411·5	39·6
Weston	71 19′ 20″ W	42 23′ 00″ N	515	442·5	52.3
Temiskaming	70 04′ W	46 40′ N	631	398·4	57·4
Ville Marie	79 27′ W	47 19′ N	637	391·8	57·7
Kirkland Lake	80 02′ 43″ W	48 08′ 57′ N	669	383.6	59.6

The intersection of these distance circles is not a true point. With the large scale used, it would vary over an area of one-half a degree in any direction. The Ottawa, Weston, Seven Falls, and Temiskaming circles intersect in almost a definite point. The Shawinigan Falls and Kirkland Lake circles are too large and that of Ville Marie is too small, so that if the best intersection is taken it will be found to be at approximately $\lambda = 70°45'0$ W. and $\varphi = 47°\ 30'0$ N. This we shall assume to be a provisional epicentre and from further study of each seismogram it will be improved upon.

The distance from each station to the provisional epicentre was computed from spherican trigonometric formulas. At this point in the study the data from the Ville Marie station were dropped. Using these distances and the travel times from Joliat's Tables, the arrival time of each expected phase was computed. The value of H used for this was 18:33:48.0, as found above. The difference (O-C) between observed and computed arrival times of all phases was then found as shown in Table III. A positive value indicates a later observed arrival time.

TABLE III

Station	Computed Δ(kms.)	P_n O−C	P_2 O−C	P_1 O−C	S_n O−C	S_2 O−C	S_1 O−C (sec)
Seven Falls	42·6	....	....	−3·1	....	....	−2·1
Shawinigan Falls	187	....	−1·5	−2·5	−2·8	....	−2·1
Ottawa	446	−1·3	−0·9	....	−3·4	....	−7
Weston	570	−6·4	−8·5	−11.5	−12·2	−14	−24
Temiskaming	637	−1·5	....	−2·7	−3·3	−3·6	−2·1
Kirkland Lake	701	−3·5	....	....	−6·6	....	−11·3

These values are all negative, Weston and Kirkland Lake being very much so. This would indicate that the value assumed for H is too late or that the computed distances are too great. From a study of the records of the nearby Seven Falls station it will be seen that this value of H cannot be changed enough to account for all the difference. If H now is taken as 18:33:47.0 the values of O-C for Ottawa, Shawinigan Falls, and Temiskaming will all be corrected. That is, the Weston and Seven Falls distances are still too great. If the Weston distance is decreased to, say, 530 kilometres, the O-C values will be brought into line with the rest of the stations. This shift, if made directly south towards Weston, will leave the Ottawa, Shawinigan Falls, Temiskaming, and Kirkland Lake distances all unchanged. Perhaps a movement slightly westward would make all the O-C values approximately zero. It will be noted that the Seven Falls station has been neglected in this discussion. But if the movement of the epicentre is south and west from the assumed position the change from the computed delta will be of the order of 30 kilometres for this station. That does correct all the readings except Kirkland Lake, to which we must give less weight on the basis that the phases recorded here are not particularly outstanding. That now leaves the following as the station-to-epicentre distances.

TABLE IV

Station	Revised Δ(kms.)	
Seven Falls	15	
Shawinigan Falls	185	
Ottawa	437	H = 18:33:47.0 G.M.T.
Weston	530	
Temiskaming	633	
Kirkland Lake	680	

This would move the coordinates in the southwest direction to 70°55′ W. and 47°20′ N. This, as may be seen, is an assumed position, but on the basis of the above argument it must be taken as the epicentre. The shift is on the strength of Joliat's travel-time tables. If, as found by J. H. Hodgson (Bulletin of the Seismological Society, Vol. 36, No. 1, 1947; Contributions of the Dominion Observatory, Vol. 1, No. 1), the P_1-phase has a 10 per cent higher velocity than that given by Joliat, and the other phases a corresponding changed velocity, this epicentre will be shifted in a northeast direction. Since there was no field investigation of the earthquake, the epicentre may be considered to be at 70°55′ W. and 47°20′ N., or on a line northeast from there but no farther than 3 to 5 kilometres along this line.

Geographical Location

This location is on the eastern boundary of Montmorency County on the edge of Laurentides Park. The epicentre may be on the upper St. Anne River only a few miles from Seven Falls. To be specific it is due west of Baie St. Paul on a line running from Lake Jacques Cartier to the St. Lawrence River.

In relation to the St. Lawrence earthquake of March 1, 1925, the epicentre appears to have moved almost straight west about 60 kilometres. It is possible that these disturbances originated on the same fault plane. There seems to be no indication of any abnormal depth of focus from the seismograms of either of these earthquakes. There was one aftershock of the present earthquake on the same day about fifteen minutes later.

Conclusions

The Province of Quebec, as can be seen from the recent earthquakes recorded, is becoming an area with considerable seismic activity. From the stations used to determine the centre of this disturbance, it appears that the areas most likely to require further seismological studies are surrounded on three sides by seismograph stations. It would not be difficult to completely circle any active area with instruments by installing a station at La Tuque or Chicoutimi. Thus with the data on travel-times now being accumulated by the observatory, and the location of the areas fairly well known, a great deal can be learned of the structures underlying certain parts of the province. It is proposed to locate each future earthquake as closely as has been done in this report and thereby increase the present knowledge of the seismicity of the Province of Quebec.

PUBLICATIONS OF THE DOMINION OBSERVATORY

VOL. VII NO. 9 1949

The Location of the Cornwall-Massena Earthquake September 5, 1944

BY

W. G. MILNE

ABSTRACT

All available seismograms and reports from field observations have been assembled and analysed for the purpose of determining the most probable location for the epicentre of this earthquake. The descriptive part of this report includes the earthquake history of the area, the surface evidence relating to the present shock, the rotation and geodetic effects, a geographical study of the region, and isoseismal data. Lists are given of the foreshocks and aftershocks, and of the seismograms used in this study. A preliminary epicentre was determined by stereographic projection methods and a more refined location was determined based only on P-phase arrival times and a least squares solution. The final epicentre was found to be at 74° 53′·9 W. Longitude and 44° 58′·5 N. Latitude, at a depth of the order of 25 kilometres. This point is located slightly north of a line joining Massena and Massena Centre in New York State.

INTRODUCTION

On September 5, 1944, at approximately 4.38 a.m. G.M.T., a large section of Eastern Canada and Northeastern United States was shaken by a moderately severe earthquake. This earthquake was reported the following morning as having been felt as far west as Detroit, east beyond Quebec City, and north to James Bay. A rough preliminary determination of the epicentre from the Shawinigan Falls and the Ottawa seismograms provisionally placed the epicentre near the International Bridge at Cornwall, Ontario.

Dr. E. A. Hodgson, of the Dominion Observatory, made a field survey of the area, the results of which were published within the next few days. This field evidence adjusted slightly the location previously determined. The Dominion Observatory then made plans to analyse all available instrumental records of the shock and to publish a report on all matters pertaining to this disturbance. This paper, which owes a good deal to Dr. Hodgson's preliminary study, outlines the pertinent field evidence plus seismograph record analysis giving a more precise location of the epicentre.

SEISMIC HISTORY

The country bordering the St. Lawrence River has been an area of frequent earthquakes as reported from time to time since the beginning of colonization. The first earthquake mentioned in Canadian historical records occurred between the two voyages of Jacques Cartier to this continent in the 1530's. The early seismic records include only severe earthquakes, since minor ones pass without mention. Dr. Hodgson, in his paper on "Industrial Earthquake Hazards in Eastern Canada", has listed all such earthquakes. No area within a considerable distance of the St. Lawrence River seems to be immune from seismic disturbances of some sort. Those listed vary from an intensity of 5 on an earthquake scale to the maximum of 10. The area around Baie St. Paul, in the lower St. Lawrence Valley, seems to be the most affected by major earthquakes. Within a radius of fifty miles of the present epicentre there were many earthquakes between 1832 and 1944. The largest, in 1861 east of Carleton Place, had an intensity of 8 as reported by Berkey. A tremor in 1937 was located between Canton and Potsdam in the State of New York. In addition to these, there were earthquakes within this radius in 1877, 1897, 1913, 1917, 1928, and 1934. That of 1917 was at Cornwall, Ontario, across the St. Lawrence River from the present earthquake.

The United States Department of Agriculture Weather Bureau reports earthquakes in the vicinity of Massena, N.Y., as follows: "October 12, November 4, 1908; May 27, 1910; October 23, 1912; April 28, 1913; February 10, 1914; October 20, 1921; December 8, 1922; February 28, 1925; March 12, March 14, 1927; March 18, 1928; August 12, 1929; November 3, 1931; November 1, 1935 (probably the Temiskaming Earthquake); March 10, 1937; November 18, 1938; May 31, 1939; May 19, December 20, December 24, 1940; February 1, 1941; July 6, 1943". The Watertown Daily Times reports earthquakes as follows: "January 22, 1832; April 8, 1836; March 1, 1838; December, 1839; and March 12, 1853".

There is no doubt that this immediate area was shaken by each of these local disturbances. In addition, the major earthquakes such as the St. Lawrence quake of 1925 and that at Temiskaming on November, 1935, probably gave the area a severe shaking.

Surface Investigations

Immediately after the earthquake, a field investigation was conducted on both sides of the International Border. In Canada, Dr. E. A. Hodgson, of the Dominion Observatory carried out a detailed study of the damage in and around Cornwall, Ontario, as well as in areas of New York State adjacent to the International bridge. Dr. Charles P. Berkey, the geologist for the United States Engineer Office, New York, conducted an investigation of the New York State side. Both of these investigators have submitted complete reports of their findings, which have been available for this study. The United States Coast and Geodetic Survey also conducted a field survey. There are reports from others who have made investigations of the area for their own interests. These will be mentioned in this paper where they have not before been reported.

Dr. Hodgson's report placed the epicentre near Massena Centre, N.Y. It is later seen that a detailed seismogram study changes this position by very little. Dr. Hodgson estimates the focal depth to be of the order of 20 miles and his report describes in some detail the visible surface damage to chimneys and monuments.

Dr. Berkey, in his very detailed report, gives an excellent account of the earthquake as described to him by residents. His description of the sounds heard in the epicentral region during the earthquake is particularly valuable. The sound is described as being "like thunder", or "a truck or train rumbling past". Dr. Berkey states that it was not possible to tell the direction of origin of these sounds from the observers' reports since

Figure 1.
Monument showing rotation effects of earthquake.

they are not at all consistent. (The sound in every case preceded the actual earthquake.) Dr. Berkey's report stresses the geology of the district and its relation to the St. Lawrence River Project.

The Inspection Department of the Associated Factory Mutual Fire Insurance Companies have submitted a detailed report on the damage to all factories in the district insured with them. The majority of their damage reports are concerned with factories within the cities of Cornwall and Massena, as is natural since they are the two large industrial cities in the area. Their damage reports, however, do not indicate that any building was totally destroyed. This fact confirms the intensity of the earthquake as estimated below.

An interesting fact regarding the damage to the cemeteries on both sides of the St. Lawrence River indicates that on one side of the river the tombstones were rotated in one sense and on the other side in the opposite sense (Fig. 1). That is to say, on the Canadian side of the river the tombstones were generally rotated counter-clockwise and on the United States side they were generally rotated clockwise. At first it would appear that there was some indication of a horizontal displacement along a fault line parallel to the river. This would indicate an origin somewhere between Cornwall and Massena, which also is confirmed from a study of the records. Such evidence is by no means exact and can only show that the epicentres, as found by field surveys and by record study, agree fairly well.

The Geodetic Service of Canada has rerun the lines of precise levels in the Cornwall area since the earthquake. There are differences present up to five-tenths of a foot, but these differences do not occur at points that would indicate that any change of level was caused by the earthquake.

A day before the Cornwall earthquake, at a few minutes past seven in the evening, three groups of independent observers reported that the waters of Lake Placid in New York State suddenly were disturbed by some unknown force. The disturbance was reported as waves of a long period on an otherwise very calm lake. One person reported a sudden upheaval followed by the swell but all three confirm the swell. This may or may not have been a forerunner to the earthquake, and there can be a great deal of doubt as to whether the two are at all related. However, such reports are noted here for future reference should they occur again.

General Geology of Area

The Cornwall-Massena area may be considered to be slightly south of the area known as the Canadian Shield, or perhaps on the border of it. It is in what is known from a topographic point of view as the St. Lawrence Plain. To the south is the Adirondack Highland of New York State. This plain is underlain by early Paleozoic sedimentary rocks. The St. Lawrence River and its many tributaries form the drainage system.

The general surface geology, as given below, is a combination of reports by Miss Alice E. Wilson, of the Geological Survey of Canada, Dr. Charles P. Berkey, and Col. A. E. Jones, of the U.S. Army Engineer Corps. In the immediate area the overburden formations are laid down directly or indirectly by glacial action. The three most probable layers of this Pleistocene age are, from the surface down, Champlain clay or marine deposits, glacial outwash, and glacial till. Below this, making up the bedrock of the Ordovician age, are the Trenton and Black River series, the Chazy formation, and the Beckmantown formation. The top two are frequently absent in the area and the Beckmantown formation provides the immediate bedrock. The Potsdam formation makes up the Cambrian rocks, whereas the Pre-Cambrian or basement for the area is the Grenville series. These formations may or may not all be present in each section and their depths vary over the shock area. However, since it is the top layer or overburden which governs the amount of damage done by an earthquake, it appears that the whole area is covered by a layer of surface material up to a depth, in some places, of two hundred feet. The loose overburden is largely responsible for the distribution and extent of the extensive damage.

Geologically speaking, the earthquake perhaps is a result of the receding glaciers of the last ice age. When a glacier lies over a region, the tremendous mass of ice depresses the surface of the earth, adjustments taking place at depth. When the glacier retreats and the ice melts, the earth rises to its former position, or beyond it. Such a rise may take many thousand years. The crust re-establishes itself upwards very slowly and since it is thought to be made up of blocks it can move more in one place than in another. When this recovery has reached the elastic limit of the rocks, there is usually some major slip or displacement along a weak spot or fault so that the stresses and strains return to equilibrium again. When this slip is instantaneous it is called an earthquake. Thus one explanation of the recurring earthquakes in the St. Lawrence region is that they are due to readjustments of the crustal layers after the recent ice age. The adjustments apparently come from deep down in the earth. Geologists report no surface evidence of any major fault in this immediate area, nor was there any noticeable ground displacement after this earthquake as there was, for example, along the San Andreas Fault following the California Earthquake of 1906.

The geological structures deeper down in the earth are less well known than those which can be probed with a drill. The chief method of determining the depth of surface layers in any area is from large scale refraction seismic methods. Earthquakes, rockbursts, or large blasts are used as a source of energy for this type of survey and the existing seismograph stations provide the instrumental records giving arrival times from each disturbance. The method so far has been rather inaccurate because earthquakes cannot be located in predetermined positions, with the result that the seismographs are not placed properly for a refraction survey. However, Leet in New England using earthquake and explosion records, and Hodgson in the Canadian Shield using rockburst records have made determinations of the depth of the crustal layers. There are considered to be several layers making up the crust down to the Mohorovičić discontinuity. The following Table I gives the results obtained by each worker in his own territory. Leet uses a three layer crustal structure to obtain his results and Hodgson a two layer crust, but both arrive at approximately the same conclusions.

TABLE I

DEPTHS OF CRUSTAL LAYERS

Layer	Hodgson (Canadian Shield) 1946		Leet (New England) 1941	
	from P	from S	from P	from S
1	17·3 kms.	16·2 kms.	16 kms.	15 kms.
2			13	10
3	18·7	19·8	7	10
Total	36·0	36·0	36	35

These two results are obtained for regions on either side of the Cornwall-Massena area so they may be considered to be valid there. Both indicate that the Mohorovičić discontinuity comes at a depth of 36 kms. below the surface, and that the first layer is some 16 kms. in thickness. It would seem likely that this particular earthquake had its origin at the boundary of one of these layers, or some intermediate depth between the two.

Isoseismal Study

Three organizations have made independent studies for an isoseismal map for this earthquake. The United States Coast and Geodetic Survey canvassed all the areas of the United States where the earthquake might have been felt. Professor John G. Woodruff, of the Department of Geology at Colgate University in Hamilton, New York, by means of a newspaper enquiry, has covered the northern part of New York State. The Dominion Observatory in Ottawa, with the help of district postmasters has covered the disturbed areas in Canada. All the data from these three surveys have been made available for the study in this report.

The United States Coast and Geodetic Survey used their own earthquake scale for their study which is adapted from Sieberg's Cancani-Mercalli scale. They prepared an isoseismal map which was turned over to the Observatory. The author has used the same intensity scale to draw the isoseismal lines for the other two surveys.

The accompanying isoseismal map, Figure 2, is self explanatory. The area of maximum intensity so determined confirms the epicentral location obtained from seismogram study. The maximum intensity at this epicentre is probably slightly more than a seven on this scale. That would not classify the earthquake as severe when compared to some where total destruction is evident over a considerable area. The area, within which the shock was felt with an intensity as great as five or six, is very small. However, as has been said before, the disturbed region extends from James Bay, south to Virginia and from New Brunswick, west to Lake Michigan. The United States Coast and Geodetic Survey estimates the area where tremors were felt in the United States as being 200,000 square miles. It is probable that the area in Canada over which the quake was felt was considerably more than twice that of the United States. In all the total was probably close to 800,000 square miles.

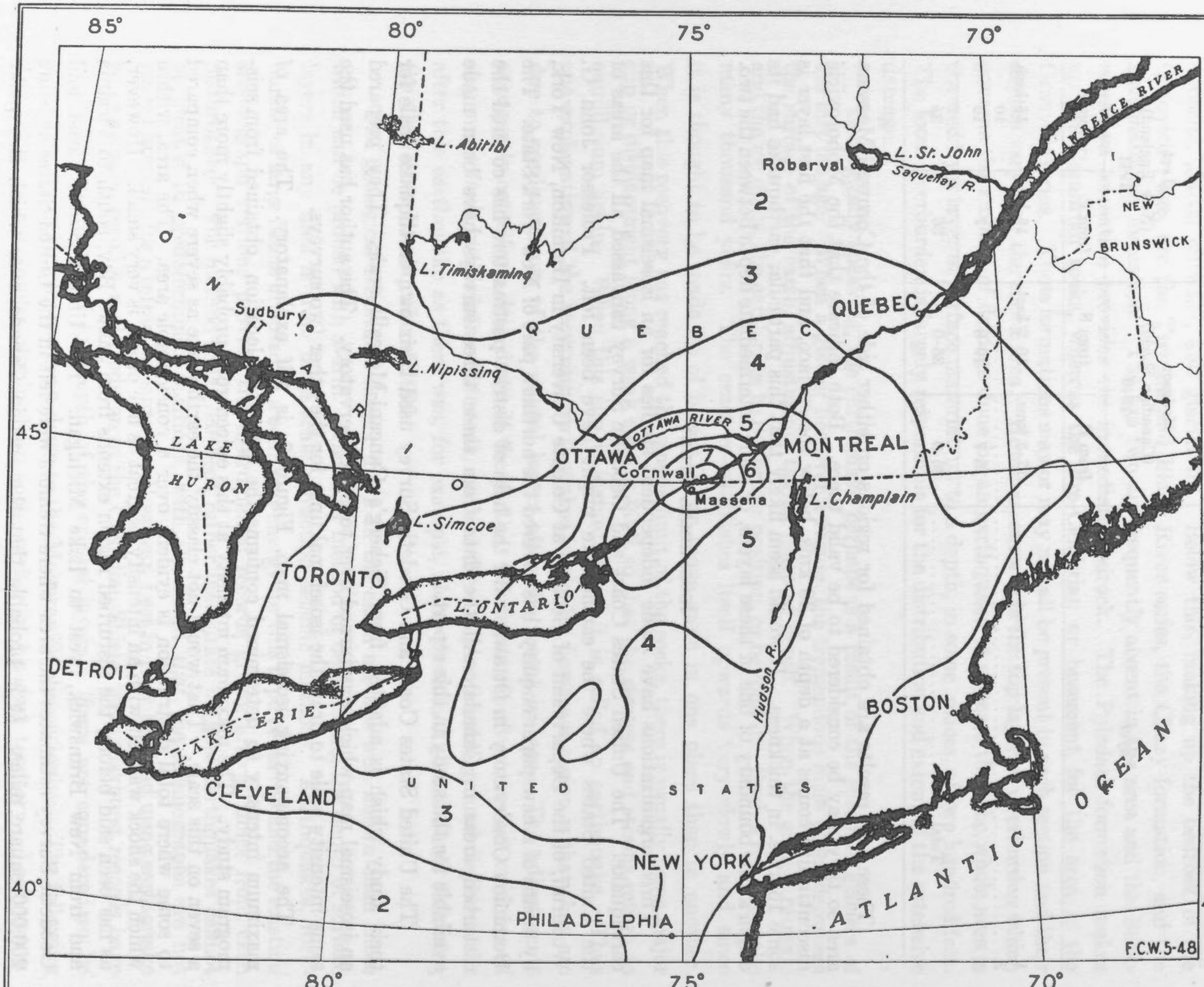


Figure 2. Isoseismal Map of the Cornwall-Massena Earthquake.

The area of greatest intensity extends farther lengthwise along the St. Lawrence River than perpendicular to it. This region where the intensities are of the order of six on the scale extends westward to the Thousand Islands at the eastern end of Lake Ontario and eastward almost to Montreal. However at Ottawa, about 90 kilometres north of Cornwall, the intensity was estimated by seismologists to be slightly less than 5 on the scale. The same condition is evident southward into the United States.

The epicentre, estimated from the isoseismal study, is at 75° W. Long. and 45° N. Lat. at the approximate centre of the concentric isoseismal lines. The centre found by the Stereographic Method and the Least Squares Method of analysing seismograms is only a matter of minutes of arc distant from this point.

Earthquake Scale Used

(Adapted by the U.S. Coast and Geodetic Survey from Sieberg's Cancani-Mercalli Scale.)

Intensity	Observed Phenomena
I	Not felt—bodies of water may be disturbed.
II	Felt indoors by some, chiefly on upper floors—doors may swing very slowly.
III	Felt indoors by several—motion is usually rapid vibration—duration sometimes estimated—hanging objects swing.
IV	Felt indoors generally—outdoors by few—hanging objects swing—dishes rattle—walls and frame of buildings creak—awakened few—vibration like passing train.
V	Felt indoors by all—outdoors by many—direction may be estimated—doors and hanging objects swung—pendulum clocks stopped—moved some objects and furnishings.
VI	Felt by all—moved furnishings—cracked plaster and some plaster fell—broke some dishes—damage slight in poorly built buildings—some bells rung.
VII	Cracked chimneys considerably—walls some—broke windows and furniture—little damage in well constructed buildings—considerable damage in poorly built buildings—frightened all.
VIII	Conspicuous movement—cracked solid walls seriously—some fell—chimneys, monuments fell—considerable damage in buildings of usual construction—wells dried—sand ejected from ground.

This scale continues beyond this to XI, but it is obvious that the intensity at the epicentre did not go beyond VIII, and probably fell somewhat short of this point on the scale. All reports are classified to fit this scale as closely as possible.

Instrumental Study

1. *Foreshocks*—From the bulletins of the Seismological Division of the Dominion Observatory for the two years preceding the date of this earthquake there are no shocks which can very definitely be said to have originated at Cornwall. However, on February 18, 1944, there was a slight tremor recorded on the Ottawa short-period Benioff seismograph which probably originated at Cornwall since its epicentral distance is of the correct order. During August of 1944, on the 9th and 10th, there were two slight earthquakes

at a distance of 95 kilometres from Ottawa which may or may not have been near Cornwall. In general, however, neither seismograph records nor reports from residents would have given any warning that a large earthquake was to be expected in the community.

2. *Seismogram Study*—The Dominion Observatory sent out a request to all seismograph stations on the continent for a loan of their records of this quake. The observatories were very kind in forwarding copies and, in some cases original records, to Ottawa for this study.

This earthquake was, relatively speaking, of small intensity. It did not register well at stations which are over 1100 kilometres from the epicentre. There are, however, numerous and very good records from many stations within this range. Thirty-five stations in all have supplied seismograms for this study, 29 of which recorded the earthquake well enough to enable a delta determination to be made from the S-P phase arrival times. This number of seismograms was reduced to 23 for the Least Squares solution because of the poor time control on some records. Thirteen of the twenty-three stations were within 1100 kilometres of the epicentre.

To show the complete figures for the solution, using all the data from all the stations, would require a great deal of space. Therefore, a list of the stations is included in Table II and the observed and computed P-phase arrival times are shown for those stations permitting an accurate reading. The detailed computations are omitted.

TABLE II

Number	Station	Δ (kms.) Computed	P–Observed	P–Computed
1	Ottawa	88·7	4 : 39 : 00·3	4 : 38 : 59·3
2	Shawinigan Falls	242·7	4 : 39 : 21·2	4 : 39 : 19·6
3	Seven Falls	395·6	4 : 39 : 39·5	4 : 39 : 41·3
4	Weston	399·1	4 : 39 : 40·6	4 : 39 : 42·8
5	Fordham	455·9	4 : 39 : 47·7	4 : 39 : 47·8
6	Philadelphia	550·4	4 : 40 : 00·6	4 : 39 : 59·8
7	Pittsburgh	648·7	4 : 40 : 14·0	4 : 40 : 14·1
8	Cheltenham	706·0	4 : 40 : 23·0	4 : 40 : 22·0
9	Cincinnati	1024	4 : 41 : 01·1	4 : 41 : 01·6
10	Chicago	1093	4 : 41 : 06	4 : 41 : 10
11	Columbia	1325	4 : 41 : 37	4 : 41 : 40
12	Saskatoon	2465	4 : 43 : 46	4 : 43 : 44
13	San Juan	3058	4 : 44 : 34	4 : 44 : 38
14	Grand Coulee	3369	4 : 45 : 00	4 : 44 : 58
15	Tuscon	3407	4 : 45 : 02	4 : 45 : 02
16	Pierce Perry	3429	4 : 45 : 03	4 : 45 : 03
17	Overton	3443	4 : 45 : 04	4 : 45 : 04
18	Boulder City	3500	4 : 45 : 16	4 : 45 : 12
19	Tinemaha	3655	4 : 45 : 27	4 : 45 : 23
20	Riverside	3808	4 : 45 : 33	4 : 45 : 35
21	Mount Wilson	3846	4 : 45 : 35	4 : 45 : 38
22	Pasadena	3861	4 : 45 : 36	4 : 45 : 40
23	Shasta Dam	3865	4 : 45 : 36	4 : 45 : 40

Assumed $H' = 4^h38^m45^s2$ G.C.T.
$\lambda = 74°50'·0$ W. Long.
$\varphi = 44° 55'·0$ N. Lat

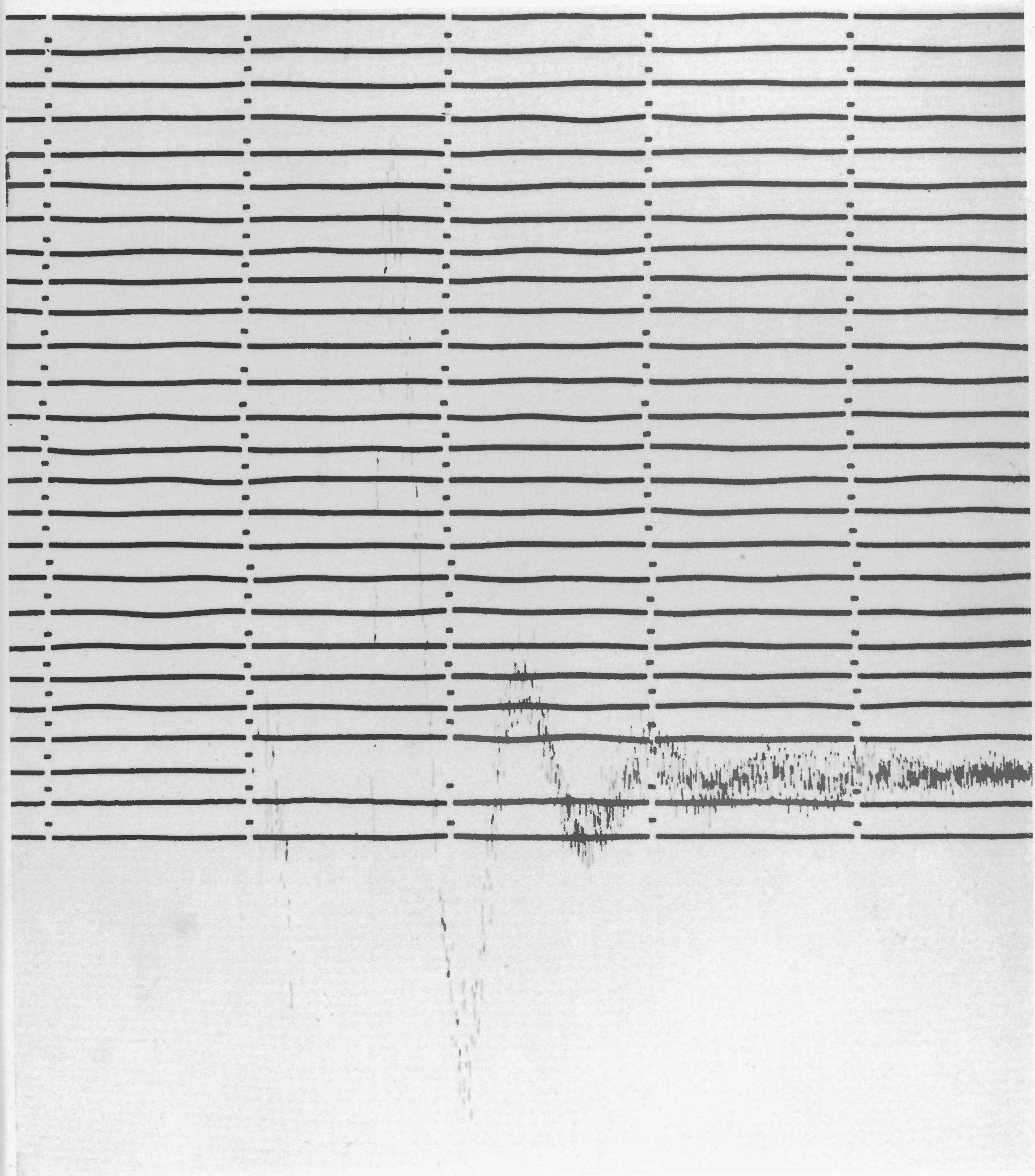


Figure 3.
Ottawa Long-period Benioff Record of Earthquake.

The first step in carrying out such a solution is to find a provisional epicentre. As many phases as possible were read from each seismogram from all stations. These phases were matched to standard seismological curves until for each station the best fit was obtained. From the S-P phase reading so obtained the station-to-epicentre distance was obtained, and H-values were computed for confirmation of these distances. Using the Klotz Stereographic Projection Method of locating epicentres, the preliminary determination of the epicentre was made. That is for each station and its proper delta, the values of d (the distance from the pole to the station projected on a plane through the pole perpendicular to the axis) and r (the projected station-to-epicentre distance) were computed. d is given as $\frac{\cos \varphi}{\sin \varphi + \cos \Delta}$ and r as $\frac{\sin \Delta}{\sin \varphi + \cos \Delta}$ where φ is the geographic latitude of the station and Δ is the station-to-epicentre distance. On a large scale stereographic map each station was located and a circle of radius "r" was drawn with the station as centre. The best intersection of these circles is taken as the provisional epicentre. In this case, as is usual, the intersection of all the circles is not a point but rather an area. When the best stations near at hand are given more weight than the distant ones and the centre of this area is taken, a fair approximation is made to the epicentre. In this case, λ was found to be 74° 50′·0 W. Long. and $\varphi = 44° 55'\cdot 0$ N. Lat. This location confirms that found by the isoseismal method.

Using the provisional epicentre and with geocentric co-ordinates, accurate station-to-epicentre distances were computed for all stations having reliable P-phase arrival times. Using these distances and observed P-phase arrival times a time-distance curve was plotted. From this curve, the average velocity of the P-phase over the distance from the epicentre to each station was found. However, the first part of the curve is a straight line, all first arrivals (except Ottawa) being the normal P-phase. The intersection of the curve with the time axis, 4:38:46·5 is taken as the provisional time of origin, H′. This velocity of the normal P-phase is found to be 8·2 kms/sec., which confirms the work done by Leet and Hodgson in the immediate area.

This velocity "m" is used with the delta value computed above for each station to obtain a computed P-phase travel time. Adding this travel time to the H′ found above, the computed P-phase arrival time (C′) is obtained. The difference between the observed and the computed P-phase arrival times (O-C′) are found in each case. These values are added algebraically and averaged. In this case, the average O-C′ for the 23 stations used was −1·31 secs. This value of 1·31 secs., if subtracted from H′ and the P-phase arrival times recomputed, would bring the O-C′ total to zero. That is, the assumed H value for this study will now be 4:38:45·1(9) which agrees very well with that obtained with an S-P computation. The new values of O-C (=E) are computed using this H value.

The method used in the following Least Squares Solution is given in "Introduction to Theoretical Seismology, Part I" by James B. Macelwane. J. H. Hodgson's modification for obtaining the average errors in the H, λ, and φ values depends upon the relation

1. $$\frac{\partial T.}{\partial \lambda}\delta \lambda + \frac{\partial T.}{\partial \varphi}\delta \varphi + \frac{\partial T.}{\partial H}\delta H = \delta T$$

where T = O-C = E for each station.

The above becomes

$$2. \quad \frac{\partial T.\ \partial \Delta.}{\partial \Delta\ \partial \lambda}\,\delta\lambda + \frac{\partial T.\ \partial \Delta.}{\partial \Delta\ \partial \varphi}\,\varphi + \delta H = E$$

It is obvious that $\frac{\partial T}{\partial \Delta}$ = m obtained above.

Also it may be proven (J. H. Hodgson) that $\frac{\partial \Delta}{\partial \varphi} = \cos E$ and $\frac{\partial \Delta}{\partial \lambda} = \cos \varphi\ .\sin S$, where the values of the symbols may be seen in Figure 4.

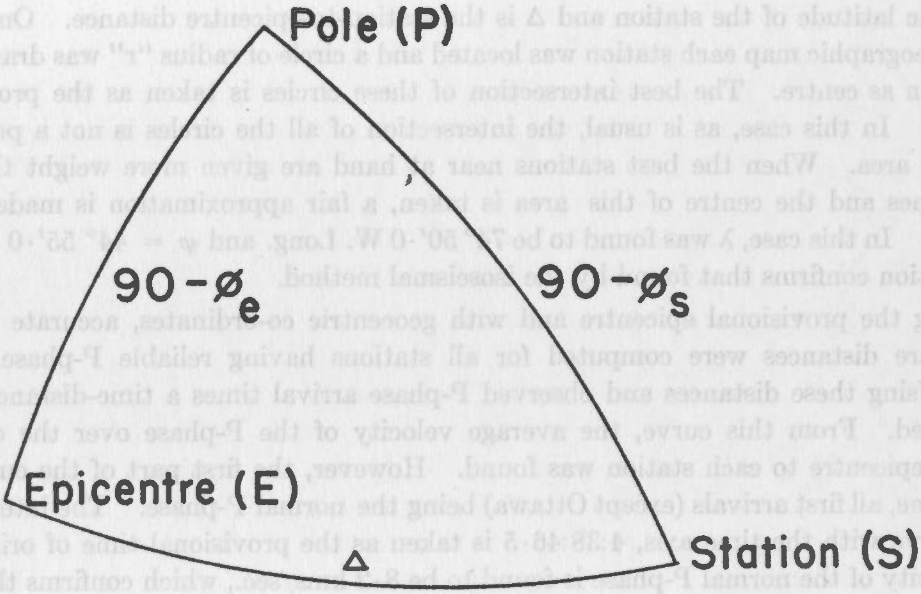


Figure 4.

These values of λ, φ, and H become x, y, and z respectively and $\frac{\partial \Delta}{\partial \lambda}\cdot\frac{\partial T}{\partial \Delta}$ and $\frac{\partial \Delta}{\partial \varphi}\cdot\frac{\partial T}{\partial \Delta}$ become a and b in the observational equation. There is now an equation of the form

$$3. \quad a_k.\ x + b_k.\ y + c_k.\ z = E_k$$

for each station (k). For each a_k, b_k, and E_k there is a computed number, 23 in all for this particular example. The problem now is to solve the 23 equations simultaneously for x, y, and z so as to best satisfy E_k. It is seen that for each equation used when the values of x, y, and z are substituted there will be a residual f_k. The values of x, y, and z to make f_k a zero have been proven to be those which make

$$4. \quad (a_k.\ x + b_k.\ y + c_k.\ z)^2$$

a minimum. Since x, y, and z are independent variables, the differential coefficient of the expression for the minimum with respect to each, must simultaneously vanish. That is

5. $$\sum_{1}^{23} a_k . (a_k . x + b_k . y + c_k . z - E_k) = 0$$

$$\sum_{1}^{23} b_k . (\quad \text{''} \quad) = 0$$

$$\sum_{1}^{23} c_k . (\quad \text{''} \quad) = 0$$

These are the usual normal equations from which are obtained the most probable values of x, y, and z, and the probable errors involved.

For the 23 equations obtained as above for this solution the following are the three normal equations:

$$+ 0{\cdot}347663x - 0{\cdot}277557y + 2{\cdot}62885z = - 0{\cdot}649386$$
$$- 0{\cdot}277557x + 0{\cdot}550867y - 2{\cdot}60446z = - 0{\cdot}594603$$
$$+ 2{\cdot}62885x - 2{\cdot}60446y + 23z = 0$$

The solution of these normal equations for the most probable values of x, y, and z, and their weights are as follows:

$$x = + 3{\cdot}859462 \qquad W_x = 0{\cdot}160063$$
$$y = + 3{\cdot}551631 \qquad W_y = 0{\cdot}373666$$
$$z = + 0{\cdot}111598 \qquad W_z = 6{\cdot}538331$$

From these values of W_x, W_y, and W_z the mean square errors and hence the probable errors (= mean square errors x·6746) are found to be as follows:

$$P_x = \pm 5{\cdot}196$$
$$P_y = \pm 3{\cdot}402$$
$$P_z = \pm 1{\cdot}676$$

The value of x was defined as $\delta \lambda$, y as $\delta \varphi$, and z as δ H so that the corrections to the assumed co-ordinates and origin times of the earthquake have been obtained.

Thus the final values of the epicentral co-ordinates are found to be:

$\lambda = 74° \; 50'{\cdot}0 + 3'{\cdot}86 = 74° \; 53'{\cdot}9$ W. Long. $\pm \; 5'{\cdot}2$

$\varphi = 44° \; 55'{\cdot}0 + 3'{\cdot}55 = 44° \; 58'{\cdot}5$ N. Lat. $\pm \; 3'{\cdot}4$ (Geographic)

H = 4:38:45·19 + 0·11″ = 4:38:45·30 hours U.T. ± 1″·68

If it were possible to measure arrival times to one-one hundredth of a second, it would be advisable to use these new co-ordinates as the assumed ones and repeat the process to give a better solution. However, for this work, the above is taken as the most probable location of the earthquake.

3. *Location of the Shock*—The above geographic co-ordinates place the epicentre of this earthquake in the State of New York, slightly north of a line between Massena and Massena Centre and slightly nearer to Massena. This location is almost on the line of the proposed Long Sault Canal for the St. Lawrence River Project. It is about two miles south of the St. Lawrence River, and almost west of the city of Cornwall.

4. *Depth of Focus*—The seismograms studied in this report did not yield any definite depth of focus for the earthquake. However, when evidence for a measurable depth is

lacking it is logical to assume that the depth is what is called normal focus. That is, the earthquake originated probably at one of the discontinuities of the crustal layers. It is generally assumed that a normal focus earthquake has a depth of focus of not more than twenty miles or thirty kilometres. That definitely would put it above the base of the crust as determined from seismic evidence.

When a travel-time curve is drawn for this earthquake and its three major aftershocks, it appears that the P-phase and the S-phase through the first layer are missing. On the basis of this evidence this earthquake had its focus between 17 and 36 kms. below the surface. In all probability it is about 25 to 30 kms. in depth.

The surface damage points to the fact that this was a normal-focus earthquake. The extent of damage decreases gradually as one moves away from the epicentre. With a deep-focus earthquake there are areas near the epicentre itself where there is very little damage whereas some area a little further away will suffer greatly. In the Cornwall-Massena earthquake there is no such evidence.

5. *Magnitude of the Shock*—The surface evidence has placed the magnitude at the epicentre at an VIII or less on a scale depending on the damage done at a point. However, there is a magnitude scale based on seismogram studies alone. By using the constants of the instruments giving the records, and substituting in formulae involving distance from the quake and periods of the wave as recorded, it is now possible to estimate the magnitude on an empirical scale. Dr. Gutenberg at Pasadena, where the scale was developed and is used a great deal, has estimated that this earthquake has a magnitude of 6 1/2 on a scale of 10.

6. *Aftershocks*—As is the case with earthquakes of such a magnitude, there were many aftershocks, probably all from nearly the same origin. These aftershocks were for the next few hours, and even for the next few days, quite severe. Aftershocks come quite frequently in the hours and days immediately following an earthquake and then over a few months they become less. They do, however, continue for months and years afterwards. That is the case with the Cornwall earthquake. There were many shocks for a while but they have gradually reached a stage in 1948 where there may be one perhaps in five or six months. The shocks are all felt in the immediate vicinity of the earthquake and there have been reports received from time to time from Cornwall of a stronger-than-usual shock having been felt. The list below is a complete record of the aftershocks of this earthquake which have been recorded on the seismographs at the Dominion Observatory up to April 1, 1948. There are, of course, many others which have been felt but were too small to record. The distances are all 90 kilometres, the same as the original earthquake, which would indicate that there has been no movement of the epicentre along a fault plane. Some of the earlier aftershocks recorded on the Shawinigan Falls seismographs and the very strong ones on the Seven Falls seismograph. No doubt some will have been recorded on seismographs in the United States which are situated at comparable distances from the original epicentre. There were 26 aftershocks to the first of 1948.

TABLE III

LIST OF AFTERSHOCKS RECORDED ON THE CANADIAN SEISMOGRAPHS

	Date		Station	Δ (kms.)	Time of First Arrival	Magnitude
1	Sept.	5, 1944	Ottawa	90	8 : 31 : 05	Weak
2	"	5, 1944	Ottawa	90	8 : 51 : 21	Strong
	"	5, 1944	Shawinigan Falls	240	8 : 51 : 41·5	Strong
	"	5, 1944	Seven Falls	410	8 : 52 : 05·5	Strong
3	"	5, 1944	Ottawa	90	10 : 57 : 07	Weak
4	"	5, 1944	Ottawa	90	11 : 11 : 09·5	Weak
5	"	7, 1944	Ottawa	90	13 : 55 : 29·5	Weak
6	"	8, 1944	Ottawa	90	10 : 11 : 30	Weak
7	"	8, 1944	Ottawa	90	19 : 35 : 36·5	Weak
8	"	9, 1944	Ottawa	90	23 : 25 : 04	Strong
	"	9, 1944	Shawinigan Falls	240	23 : 25 : 25	Strong
	"	9, 1944	Seven Falls	410	23 : 25 : 48·5	Strong
9	"	13, 1944	Ottawa	90	22 : 00 : 43·5	Weak
10	"	24, 1944	Ottawa	90	19 : 30 : 41·5	Weak
11	Oct.	4, 1944	Ottawa	90	0 : 36 : 41	Weak
12	"	9, 1944	Ottawa	90	1 : 46 : 11·5	Weak
13	"	13, 1944	Ottawa	90	2 : 34 : 03	Weak
14	"	31, 1944	Ottawa	90	8 : 42 : 40·5	Strong
	"	31, 1944	Shawinigan Falls	240	8 : 43 : 01·5	Strong
	"	31, 1944	Seven Falls	410	8 : 43 : 25	Strong
15	July	24, 1945	Ottawa	90	1 : 56 : 32	Weak
16	Dec.	2, 1945	Ottawa	90	15 : 22 : 45	Moderate
	"	2, 1945	Shawinigan Falls	240	15 : 24	
17	May	22, 1946	Ottawa	90	14 : 28 : 10·5	Weak
18	"	22, 1946	Ottawa	90	14 : 30 : 16·5	Weak
19	Sept.	4, 1946	Ottawa	95	19 : 29 : 36	Weak
20	Nov.	24, 1946	Ottawa	90	10 : 20 : 59·5	Weak
21	Dec.	25, 1946	Ottawa	90	4 : 48 : 16·5	Moderate
	Dec.	25, 1946	Shawinigan Falls	240	4 : 49	Moderate
	Dec.	25, 1946	Seven Falls	410	4 : 50	Moderate
22	Aug.	4, 1947	Ottawa	90	8 : 26 : 01	Weak
23	"	14, 1947	Ottawa	90	2 : 18 : 48·5	Weak
24	Sept.	6, 1947	Ottawa	100	21 : 35 : 24·5	Weak
25	Oct.	3, 1947	Ottawa	90	15 : 28 : 47·5	Weak
26	"	29, 1947	Ottawa	95	15 : 45 : 50	Weak

In addition to these recorded aftershocks, there have been, from time to time, reports received at the Observatory of tremors which were actually felt at Cornwall. The dates of these are as follows: Oct. 28, Oct. 29, Nov. 4, 1944; Jan. 8, Jan. 9, Feb. 13, Feb. 27, and June 4, 1945. In all probability there will have been many more which go almost unnoticed.

CONCLUSION

This report, in every section of its study, confirms the conclusion that the epicentre of the earthquake of September 5, 1944, had its epicentre slightly north of the line joining Massena and Massena Centre in the State of New York. There were, with the exception of three very small foreshocks which could have indicated nothing, no warnings of the coming of the earthquake. There have been many aftershocks which have, over a period of years, gradually decreased in number until at the present time they are far and few between. These aftershocks have diminished greatly in intensity. The damage, which was estimated to run to a high figure, was unusually great although the quake was not intrinsically severe. It happened to be centred in a heavily populated region.

The main shock of this earthquake occurred at $4^h\ 38^m\ 45^s \cdot 3$ G.C.T. It is estimated to have had an intensity of VII + on the modified Cancani-Mercali Scale used. It was felt over a considerable area in Canada and the United States. However, as compared with other earthquakes in Canada and other parts of the earth, it was quite small. There is no way of foretelling if there will be more shocks in the area but certainly this area of Canada appears to be fairly seismic.

Acknowledgments

In concluding the paper the writer wishes to express his indebtedness to members of the staff of the Seismological Division who, at the time of the earthquake, gathered together the material for a detailed study. Thanks are also due to the individuals and organizations mentioned in the text who have contributed a great deal of information. It is a pleasure to have had such complete co-operation from United States seismologists in carrying out the study of an earthquake whose epicentre was so close to the International Border.

References:

1. Berkey, Charles P., "A Geological Study of the Massena-Cornwall Earthquake of September 5, 1944, and its bearing on the Proposed St. Lawrence River Project", confidential mimeographed report for United States Engineer Office, New York, 1944.

2. Hodgson, E. A., "Industrial Earthquake Hazards in Eastern Canada", Bulletin, Seismological Society of America, Vol. 35, No. 4, October, 1945.

3. ——————— "The Cornwall-Massena Earthquake, September 5, 1944", Journal of the Royal Astronomical Society of Canada, Vol. 39, No. 1, January, 1945.

4. Hodgson, John H., "On the Differential Coefficients in Geiger's Method of Locating Epicentres", Bulletin, Seismological Society of America", Vol. 27, No. 2, April, 1937.

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PUBLICATIONS

OF THE

Dominion Observatory

OTTAWA

VOL. VII NO. 10

Seismology

The Saint Lawrence Earthquake

March 1, 1925

BY

ERNEST A. HODGSON

OTTAWA

EDMOND CLOUTIER, C.M.G., B.A., L.Ph.,

PRINTER TO THE KING'S MOST EXCELLENT MAJESTY

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1950

PUBLICATIONS OF THE DOMINION OBSERVATORY

VOL. VII NO. 10

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ABSTRACT

The Saint Lawrence Earthquake, the latest in a long series of severe shocks originating in the lower St. Lawrence valley, occurred at $9^h19^m20^s$ p.m. E.S.T. Saturday, February 28, 1925. It caused wide-spread damage in the region east of Quebec city, particularly north of the river, including the towns in the vicinity of Lake St. John. The damage in the city of Quebec was serious but confined almost altogether to the section known as Lower Town. Considerable damage was also found on deep alluvium locations to the west of Quebec especially in Three Rivers and Shawinigan Falls.

The epicentre was located by means of seismograph records. The earthquake was studied in the field and by means of widely-distributed questionnaires. This paper presents the data obtained in these studies and indicates the position of the epicentre as Lat. 47°.6 N.; Long. 70°.1 W. These coordinates define a point in the St. Lawrence river between the mouth of Malbaie river on the north shore and the mouth of Rivière Ouelle on the south.

As this earthquake is one of a long series of heavy shocks recorded historically as having occurred at intervals since the voyages of Cartier, a summary is given of the known records and their publication data.

INTRODUCTION

The Saint Lawrence Earthquake has been the subject of continued investigation by the Seismological Division of the Observatory. The following interim reports have been published:

1. "Preliminary Report on the Saint Lawrence Earthquake, February 28*, 1925" (in French and in English), 3 pages, mimeographed for distribution, Ottawa, March 23, 1925.

2. "The Saint Lawrence Earthquake of February 28, 1925" (Text of a paper presented before the Royal Society of Canada), 4 pages, mimeographed for distribution, Ottawa, May 20, 1925.

3. "The Saint Lawrence Earthquake, February 28, 1925" (Text of a paper presented before the Portland, Oregon, meeting of the Seismological Society of America, June 19, 1925), *Bulletin of the Seismological Society of America*, Vol. 15, No. 2, 1-16, 16 half-tone reproductions from photographs, Stanford, June, 1925.

4. "Rotation Effects of the Saint Lawrence Earthquake, February 28, 1925", *Journal of the Royal Astronomical Society of Canada;* Vol. 19, No. 6, 169–178, 1 map, 6 half-tone reproductions from photographs, Toronto, October, 1925.

*February 28, 21^h, E.S.T. or March 1, 2^h, G.M.T.

5. "The Saint Lawrence Earthquake" (A short article prepared for *The Canadian Review*), 1 page, Ottawa, May 14, 1926.

6. "The Saint Lawrence Earthquake, February 28, 1925". (A final analysis of the data collected), *Transactions of the Royal Society of Canada*, Third Series, Vol. 21, Section IV, 145-152, Ottawa, 1927.

7. "Tremblement de terre sur les rives du Saint-Laurent le 28 février 1925." (Analyse finale des données recueillies), *Bulletin de la Société de Géographie de Québec*, Vol. 22, Nos. 1 and 2, 56-64, Quebec, January-May, 1928.

As might be expected, some earlier conclusions, tentatively adopted in the interim reports, have been amended in the light of further investigation. Especially is this true with regard to the position of the epicentre. The first three of the above-mentioned reports favour the possibility of the epicentre being "near the eastern boundary of the Laurentides Park", rather than the alternative possibility now adopted. One point which lent weight to the location being so far north was a story that the ice in Lake Cartier had "exploded" at the time of the earthquake. That is to say, the ice of the entire lake had been broken up. After repeated attempts to obtain an interview with some responsible persons who had been there at the time, an opportunity presented itself, on July 21, 1926, to meet Mr. Michael Fragasso, an engineer, in charge of construction work on that lake at the time of the earthquake. The information given by him contradicted the circulated reports. This contradiction, coupled with further study of the damage at Rivière Ouelle, has led to the above location being abandoned in favour of the other alternative, i.e., in the bed of the Saint Lawrence between Rivière Ouelle and Malbaie.

In the present, final and complete publication, an attempt is made to show the extent of the observational data and to outline some typical and important parts of it. To avoid interfering with the systematic development of the subject, it is thought best to relegate to appendixes certain related subjects, which have a bearing on the investigations of the seismicity of the Saint Lawrence valley.

1. GENERAL DESCRIPTION OF THE EARTHQUAKE

(1) *Summarized details*

The Saint Lawrence earthquake occurred at $2^h\ 19^m\ 20^s$ G.M.T. March 1, 1925, ($9^h\ 19^m\ 20^s$ p.m. E.S.T. Saturday, February 28, 1925). It was felt strongly over Eastern Canada and the New England States. Replies to questionnaires reveal the fact that the tremors were felt as far south as Virginia, as far west as the Mississippi, as far east as the Atlantic and at least as far north as a lone camp some 80 miles above lake Saint John. Records were obtained at practically all the seismographic stations in the world, very complete and well-marked ones being registered as far west as Victoria, B.C., as far east as Central Europe and as far south as La Plata. The area of maximum damage was confined to a narrow belt, approximately 20 miles long, covering both sides of the Saint Lawrence, somewhat less than 100 miles below the city of Quebec. Besides this damage indicating the position of greatest disturbance, there was some, due to the soft soil beneath heavy buildings, in less disturbed regions, notably at Quebec and in the valley of the Saint Maurice river.

The epicentre may be considered as having occurred on a fault line crossing the Saint Lawrence near the mouth of Rivière Ouelle (about 90 miles below Quebec city), entering the south shore to near Saint Pacôme, and extending into the north shore, up (perhaps) one or both the rivers Malbaie and Gouffre. The earthquake probably consisted of a sharp upward thrust on the northeast side of the fault, coupled with a strong horizontal movement toward the northeast in the case of the southwest side.

The causes advanced for this earthquake are a major, underlying one, due to an accumulation of stress caused by a slow rising of the Atlantic coast, and several "trigger" causes. Among the latter may be mentioned the Sayles theory of the effect of long periods of drought on a rising section of the coast, and also the estuary tide effect, virtually warping up the outer (east) side of the fault, due to a high tide, well inside the fault line zone, and a low tide outside that zone—the conditions which obtained at the time of the earthquake.

(2) *Areas of greatest severity*

The areas of greatest severity were three in all. The first of these was in the immediate vicinity of the epicentre (Baie Saint Paul, Saint Urbain, Les Eboulements, Pointe au Pic, Malbaie, Tadoussac and villages adjacent to these on the north shore of the Saint Lawrence; and Sainte Anne de la Pocatière, Saint Pacôme, Rivière Ouelle, Saint Philippe, Saint Denis, and Saint Pascal on the south shore), where the damage was due to the strength of the tremors, aggravated in some cases, notably at Baie Saint Paul, Saint Urbain, and Rivière Ouelle, by the deep alluvial soil on which the damaged structures were built. The damage at the other two locations (Quebec and Trois Rivières–Shawinigan Falls) was due, not so much to the intensity of the shock, as to the unstable nature of the terrain.

At Quebec the area of greatest damage was confined to a narrow belt bordering the Saint Charles river, where a heavy grain elevator and loading equipment is built on deep, made ground, held in place by piling driven along the edge of the river.

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At Trois Rivières, the damaged structures were built on the deep alluvium in the delta of the Saint Maurice river. The serious damage at this point was confined to structures which were particularly top heavy. At Shawinigan Falls, unstable foundation soil was mainly responsible for the damage, but poor construction, either as regards the material or the design, or both, was an added factor of importance. The damage at the various places may, conveniently, be discussed in the order in which they are named above.

Baie Saint Paul—This town is situated in the delta of the Gouffre river, which, although a comparatively narrow stream throughout its course in the "mountains" immediately to the north, is at least half a mile wide at its mouth. The mountains, so-called, are from 900 to 1,400 feet high in the vicinity of Baie Saint Paul. They are really the dissected edge of the high plateau of the Canadian Shield, at this position about 3,000 feet above sea level. The mountains several miles inland have their tops at the level of this peneplain, rising to 2,000 feet or more above the level of the Gouffre river. The terrain on which Baie Saint Paul is built is deep alluvium. A well near the railway station is said to be dug to a depth of 80 feet through sand and clay.

The fact that this town is less than 25 miles from the epicentre, coupled with the factor of alluvial terrain, resulted in very general distribution of minor damage—fallen chimneys, broken windows, overthrown dishes, etc. It is a fortunate circumstance that most of the houses are built of wood. There are but few brick houses. The chief stone structure is the Catholic Church, at which place the greatest damage was sustained.

The great tower of this church is 150 feet high. Two of the large bells were thrown out of their bearings. The swaying of the tower dislodged about a cubic yard of stone from the inner side of the top of the tower immediately below its bell canopy. The church was just being newly decorated. The dust from the fallen stone and the plaster dislodged at the juncture of the ceiling with the tower wall were thus particularly noticeable. The damage was not nearly as serious as was reported at the time. Within a week the repairs required had been completed and the church showed little effects of the earthquake.

There were several points where minor damages were more serious than elsewhere. Probably the greatest loss occurred in the drug store of Dr. E. Allard. Practically all the bottles fell from the shelves, which are arranged around three sides of the store. Within a week after the earthquake, all the shelves had been equipped with battens nailed part way up the face to prevent a recurrence of the damage. The battens were enamelled to match the shelves and were designed as a permanent equipment. This seems to be one of the few cases where reasonable precautions have been taken in expectation of a recurrence of the earthquake.

The great stove in the Hotel Seymour was upset but no fire resulted—a rather remarkable circumstance which was true throughout the entire epicentral district in which many stoves were overturned at a time when the weather was very cold and when, in many cases, the householder rushed from his home in terror.

The Hospice de Sainte Anne is built of brick. It suffered a cracked wall which did not appear to be at all serious.

Saint Urbain—The village of Saint Urbain lies in the valley of the Gouffre river 8 miles above Baie Saint Paul. It is at an elevation of about 400 feet, the valley floor being a mile and a half wide at that point. The houses are built on clay. Magnetic oxide of iron is mined on the mountain just west of the village.

The breaking of chimneys and windows was the general type of damage sustained. As all the houses are of frame construction they were otherwise unharmed. The church is built of stone. It is very old and had survived the earthquake of 1870. The present earthquake practically wrecked the building. The spire tilted toward the northeast at a dangerous angle. Examination showed that the cross timbers in the spire were badly cracked and splintered. It fell at 3 a.m., Wednesday, March 11, 1925, breaking the telephone line connecting Chicoutimi with Quebec.

Between Saint Urbain and Baie Saint Paul cracks opened in the frozen floor of the valley. Water and sand oozed through these cracks. The water-table is only 4 feet below the surface at the point where the largest of these cracks occurred. It was visited about ten days after the earthquake. The crack ran for some 60 feet parallel with a steep bank to the west of it and with a steep drop toward a pond to the east. The frozen surface merely slipped over the water-table horizon toward the lower level of the pond, (see page 434). This crack was reported over most of the lower Quebec country at the time of the earthquake.

A description of the topography and geology of the valley of the Gouffre river is given by Dr. J. B. Mawdsley in a report entitled "St. Urbain Area, Charlevoix District, Quebec." (Canada Department of Mines, Geological Survey, Memoir 152, Ottawa, 1927).

Les Eboulements—This village lies approximately 9 miles down stream from Baie Saint Paul, on the north shore of the Saint Lawrence. It was not visited. The following is an abstract of the replies to a questionnaire returned by the postmaster at Les Eboulements: The first shock lasted thirty-five seconds. Many shocks of lesser intensity were felt during the ensuing night, and for some three weeks afterwards. The earthquake was accompanied by a very loud noise. Plaster was cracked generally. Thirteen chimneys were broken. Stone houses were cracked in several cases, on the sides facing northwest. The chimneys fell toward the northwest.

Pointe au Pic—The village of Pointe au Pic and that of Malbaie (Murray Bay) adjoin. In these two villages and to the northeast of them the damage on the north shore was greatest. At Pointe au Pic most of the chimneys were broken. Fire-place masonry was cracked and twisted. Heavy objects shifted. Statues rotated or fell. A report that one house has shifted on its foundations was investigated and found untrue. The houses in this village are built on much more solid foundations than is the case at Baie Saint Paul. In many cases they are on rock. Had this not been so the damage would certainly have been much greater. The main earthquake was so severe that it was felt by the train crew on a moving engine, which was approaching Pointe au Pic at the time.

Malbaie—This village is built partly on rock and partly on alluvium, at the mouth of the Malbaie river. The difference in the damage for the two types of terrain is very marked. Two seriously damaged structures were the jail at Malbaie and an old manoir house a mile or two down stream from that village on the banks of the Saint Lawrence. The jail is massively constructed of stone. At the time of the earthquake it was occupied by the jailer and his family and one prisoner. The building was badly cracked throughout. The courtroom was a wreck of fallen plaster. The noise of the banging cell doors and the falling stone and plaster was terrifying. The jailer reported that the shocks continued all night at short intervals with hardly any respite. Here, as in many places in the epicentral area, no one attempted to sleep all night.

The manoir house is also solidly constructed of stone. It is very old, the "modern end" having been built fifty-two years ago. As a result of the earthquake, the great chimneys at each end of the house sagged out several inches at the top, breaking connection with the roof and ripping the floors. The south wall bulged out at the top. The verandah sank and sagged out from the wall. Rifles and pictures were thrown wide of the walls on which they had been hung.

The church at Malbaie is on solid rock. Thus, although it is constructed with stone front and plaster walls, the bond between these forms of construction did not break. One could hardly ask a better example of the difference between damage to structures on rock and those on alluvium than that afforded at Malbaie (and also at Quebec city. *See* page 382).

Several stoves were upset by the earthquake in the vicinity of Malbaie, some of them being on the second floor of the house. No fires resulted, which was most remarkable considering the circumstances.

In many cases the chimneys at Malbaie were "twisted off". That is, they fell in a manner which left the bricks strewn out in a sort of spiral from the foot of the chimney. Some which remained in place but distorted showed this same "twisting". The successive jars seemed to break the bond of the mortar and the bricks, catching first at one point than at another, which caused the chimney to rotate as the bricks loosened from the chimney block in the course of disintegration.

The inhabitants of Malbaie and Pointe au Pic were much disturbed by the earthquake. Many wished to leave the area during the period of the aftershocks. Some did move temporarily to Quebec city.

Tadoussac—It was not possible to pay a visit to Tadoussac at the mouth of the Saguenay river. Several telegrams were exchanged with the mayor of that village, and questionnaires were returned by three representative citizens. Chimneys were broken generally. As a rule these fell to the east. The noise of the various shocks arrived from the west before the tremors were felt.

Between Malbaie and Tadoussac is the lighthouse station of St. Simeon. Mercury was spilled from the light float and the usual damage of broken chimneys was experienced. It was not found possible to visit the place but questionnaires were returned by the parish priest of this village and also by the parish priest of Saint Hilarion a few miles east of Saint Urbain.

Sainte Anne de la Pocatière—The point on the south shore, eastward from Quebec city, at which the area of greatest damage first appears is the village of Sainte Anne de la Pocatière. True, damage was reported from other places—Montmagny, Saint Jean Port Joli, Sainte Louise, etc.—but it was little more than the breaking of a few chimneys, presumably of poor construction, the cracking of the snow-covered surface of the ground, and the rotating of a few monuments which were, in some cases at least, not well placed.

At Sainte Anne the damage was very marked. Part of the village is on a rocky ledge, part on an alluvial plain. Damage was general throughout the entire village but was greater on the alluvium. Most of the chimneys in the village were thrown down; brick walls were cracked; frame houses were twisted out of shape in a few cases; plumbing was broken; the plaster tops of pillars in the chapel of the college were destroyed; some monuments in the cemetery were thrown down while many others were rotated; crockery was broken throughout the village; the snow which was frozen hard at the time of the quake was cracked generally in this district; the frozen earth beneath the snow was cracked into huge rectangular grids; water conduits buried in the ground were broken.

Saint Pacôme—This village is built close to a rocky outcrop to the south of the valley of Rivière Ouelle. The destruction of chimneys was general. Some were twisted and others were thrown off in a solid block, the mortar having broken at one joint only. Stoves were upset or moved along the floor. A heavy safe, on rollers, was shifted for a distance of more than a foot. The frozen road surface was cracked more or less regularly at distances of 100 feet or less, in some places as close as every 15 feet. A great crack opened in the clay at a point where the floor of the valley rises to the cliff.

At the railway station, which is about a mile from the village, 48 panes of glass were broken. The stoves shifted toward the east. The stove in the men's waiting room

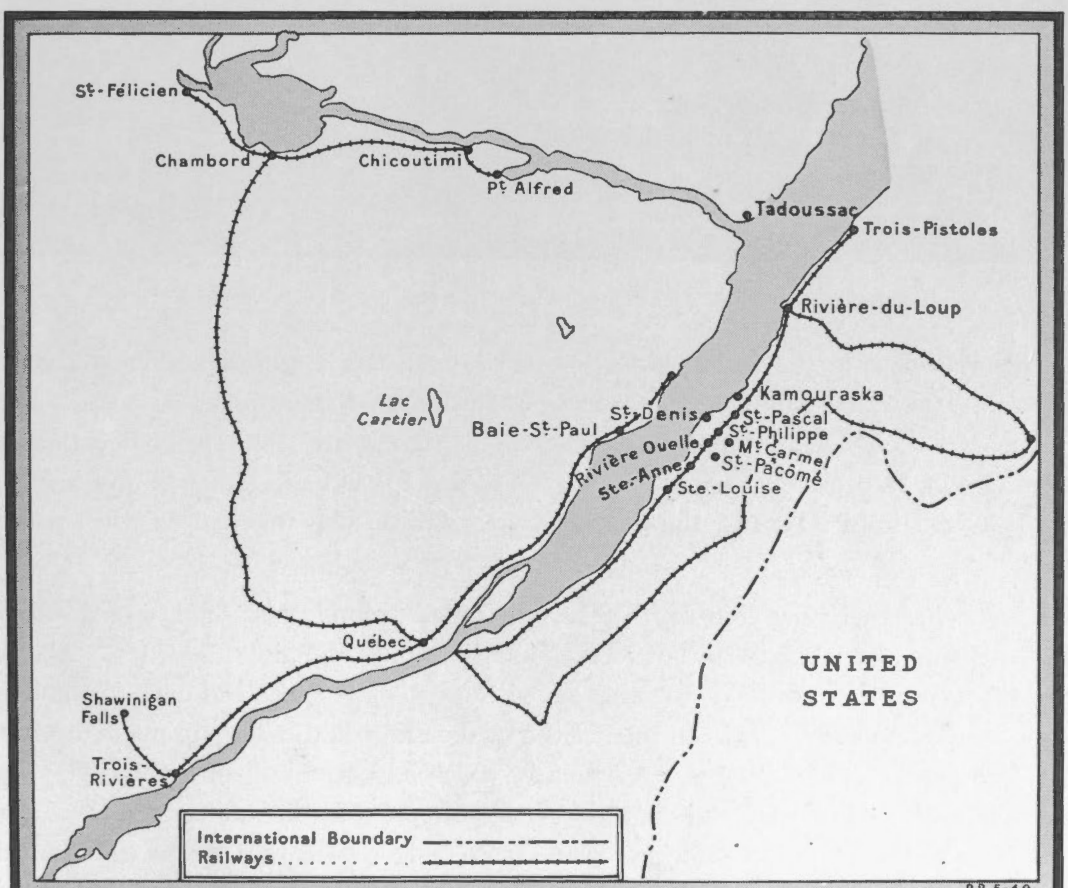

FIG. 1.—Map of epicentral region

moved east several feet by a series of jumps as was evidenced by marks on the floor. A cook stove moved east in the kitchen. A heater in the living quarters upstairs moved east. The ceiling fell in the dining room. The piano turned contra-clockwise. A cupboard fell toward the east. A latched door, fastened with a wedge before the earthquake, was found open afterwards. The boards forming the wall of the men's waiting room had had a hole cut through for a stove pipe which was no longer in use, the hole being covered with a piece of tin securely held in place with many short nails. The tin was worked and buckled until it was quite out of shape but it was still in place.

At the time of the quake, the operator, who lives at the station with his family, was at the telegraph key. The earthquake struck *without a preliminary sound warning* as a single sharp bolt *from below*. The stove in the ladies waiting room broke in half. The section with fire in it rolled into the centre office and had to be rolled out in the snow. The shocks continued to be felt at intervals during the night.

FIG. 2.—Looking north over the valley of Rivière Ouelle from Saint Pacôme

This station is in the valley of Rivière Ouelle (*see* figs 1 and 2.). The soil is deep alluvium. The water table is only a couple of feet below the surface. The station is of frame construction. The stations on either side of it (Sainte Anne de la Pocatière and Rivière Ouelle, respectively) are of brick. The former was badly cracked and has some brick dislodged from its walls, the one at Rivière Ouelle was wrecked as will presently appear.

Rivière Ouelle—Every chimney for several miles around this point was destroyed. Only three stone buildings were between the station and the Saint Lawrence. All three were destroyed. Two were old stone houses with great walls 2 feet and more in thickness. The owners had to rush out at the time of the quake and could not again make use of the houses. The church was a fine stone structure which had been built in 1872. The organ pipes were projected upward and outward so that they fell in the auditorium clear of the choir loft. The stones of the wall were jarred loose (*see* fig. 3) so that the tops of the walls, especially in the transepts, were thrown down (*see* fig. 4). The great stone chimney was thrown down and crashed through the roof.

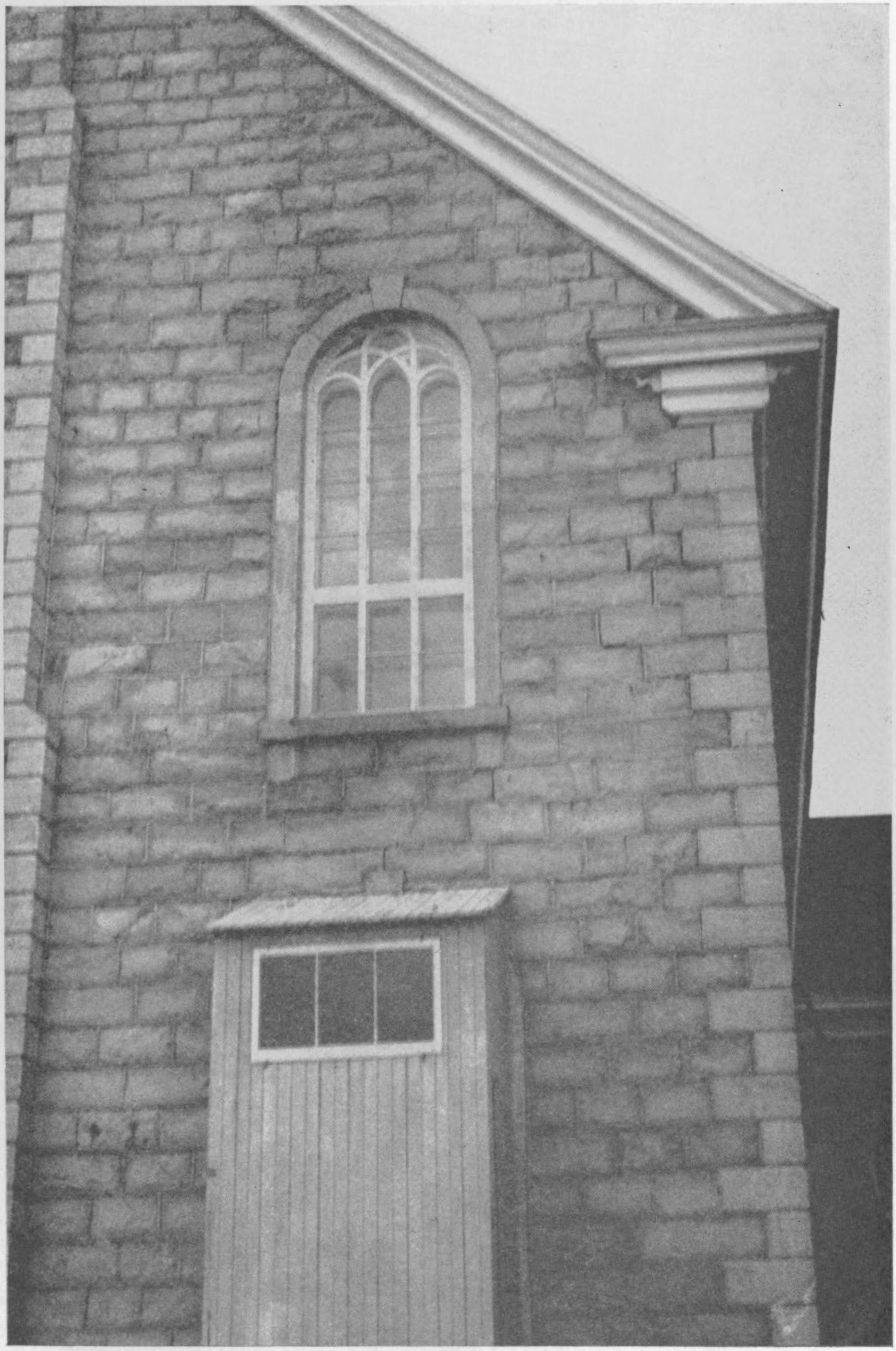

FIG. 3.—East side of front of Rivière Ouelle church

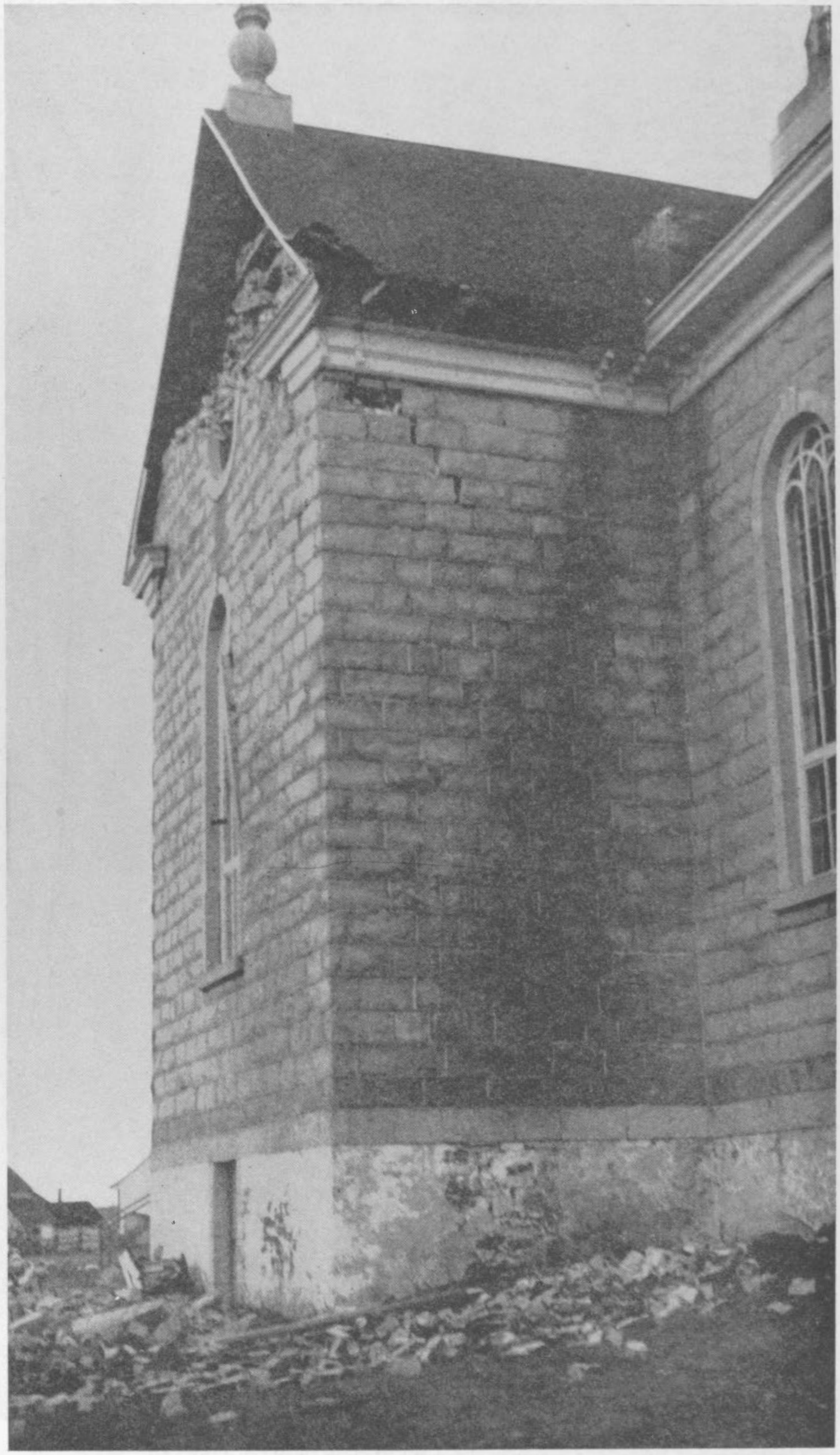

FIG. 4.—West transept wall of Rivière Ouelle church

In the churchyard, the monuments were generally thrown down or rotated (*see* figs. 5, 19, 20, 21). There were three graveyards of different age. In the oldest there were only a few flat headstones. These were probably fallen before the earthquake. Certainly none remained standing afterwards. The second oldest section has stones of various types in it but they were possibly in need of some re-setting previous to the quake. Nearly all were damaged in some way but the fall of the upper sections was in different directions depending on the way the respective monument was tilted out of plumb. The latest section had new stones, well set up and in good order. These were either rotated or thrown down. Every stone in this section which fell lay to the southeast (*see* fig. 5).

The soil at the position of the church and graveyards is very deep. Just in front of the church a bridge crosses Rivière Ouelle. The parish priest furnished the information that the foundation of this bridge rests on piles driven down through 90 feet of sand.

A great crack formed beside the roadway about a mile from the church (*see* fig. 17). The crack is parallel to the river bank which is about 33 feet distant. Six weeks after the earthquake, the crack was still visible and could be followed for about 100 feet, the edges being from 2 to 3 inches apart. At the time of the earthquake the crack could be followed for 150 feet and a stick could be thrust into it to a depth of 20 feet.

At the time of the earthquake a number of persons had gathered at the station at Rivière Ouelle to wait for the train from Lévis, which was just about to leave Sainte Anne de la Pocatière when the earthquake occurred. The shock arrived at Rivière Ouelle without warning as a single sharp jolt from below, followed by later oscillations. The first blow threw out the station wall from foundation to roof.

Saint Philippe—The houses in Saint Philippe are on rock or near rock. They are invariably frame. The station is of solid brick and suffered a crack in the east wall. Part of the west wall fell after the earthquake. The church is of cut stone. It was not damaged, nor was any appreciable damage noted in the cemetery. The road running from Saint Philippe to Saint Denis, toward the Saint Lawrence, crosses a level stretch of valley floor. It was cracked at intervals as was that at Saint Pacôme (*see* fig. 16). That the shock was severe at Saint Philippe is evidenced by the fall of a chimney on a comparatively new house. This chimney had evidently been built on a platform inside. At the time of the earthquake it was dropped down into the house. The fall of chimneys built in this way is a serious menace in a country liable to earthquakes. It is astonishing that no one was injured with destruction of chimneys so general. The story is told of one case in this section where a child had just stepped out of a bed when the earthquake occurred, piling the bricks on the pillow.

Saint Denis—This village lies between Saint Philippe and the Saint Lawrence. It has but few houses. The church has an extraordinarily high steeple. This steeple swayed so that the joint between the roof and the wall was chipped. Statues, etc., in the church fell southeast. Some of the stones turned in the small graveyard. Several stories were told of strange lights seen from this village hovering over the Saint Lawrence. The parish priest explains these by saying that the light was due to the setting moon then about six days old which was partly obscured by clouds.

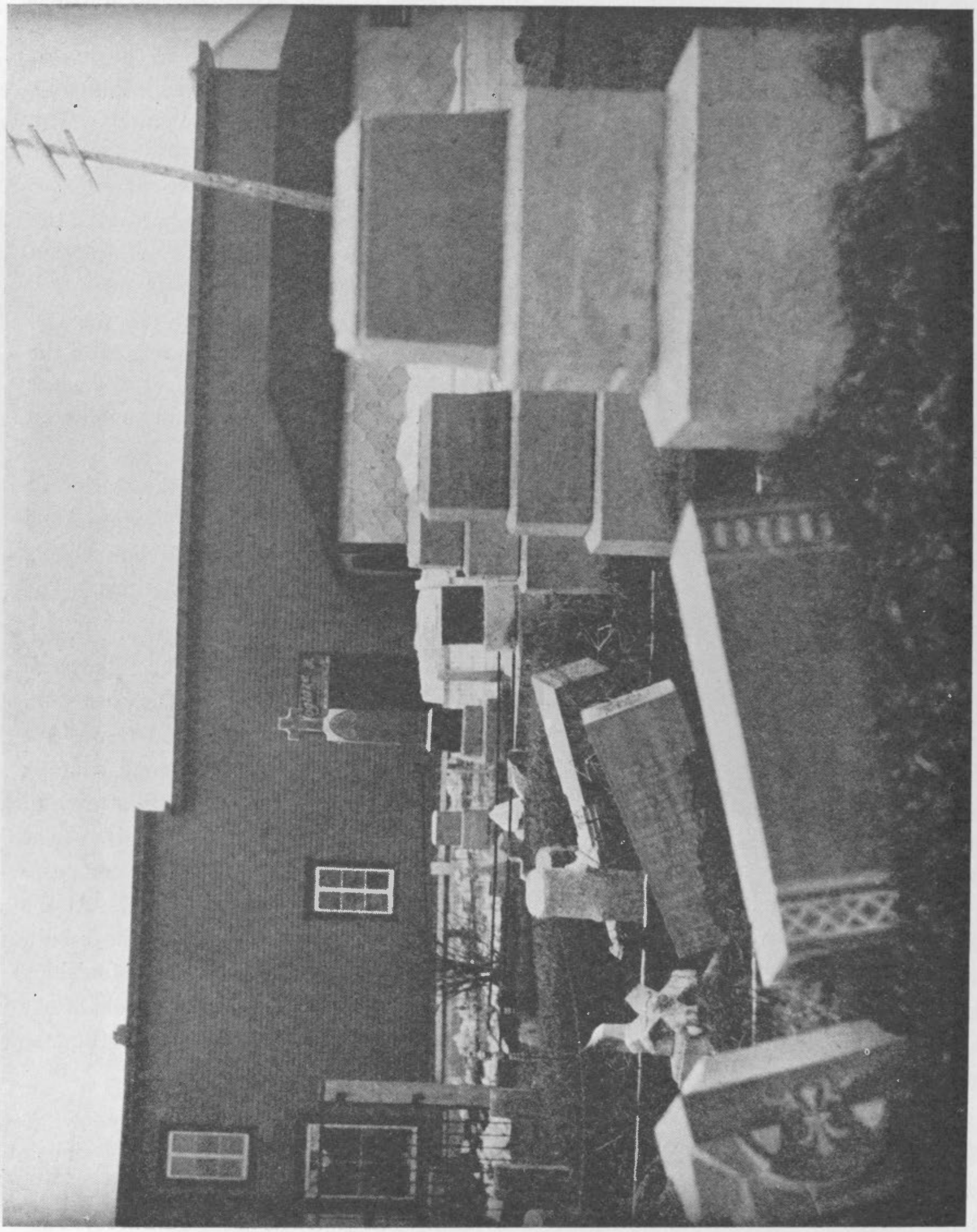

FIG. 5.—Monuments all fallen eastward, Rivière Ouelle cemetery

Saint Pascal—The church in this village is a very fine one. Four statues of angels are mounted at the corners of the spire roof. These are of large size but were not displaced by the earthquake. The church walls are very thick. They were very much cracked at the time of the earthquake. A photograph taken about a year later (*see* fig. 6) shows these cracks repaired and indicates that they spread over the entire wall. It is said that a statue in this church was thrown upward and outward by the shock so that it cleared the candelabra of electric lights which was fixed above it. The ring of lights was certainly large enough to permit the statue to clear them but it is more than probable that it fell and rolled under. Every statue but one in this church was thrown down. Stones in the graveyard adjoining were rotated or thrown down, except the flat headstones which were not affected. It is said that repairs to this church cost $5,000.

The solid brick station was cracked on one side. Chimneys in the village were generally thrown down but not in all cases. Except for the church, little serious damage resulted from the earthquake. This same church suffered during the earthquake of 1870.

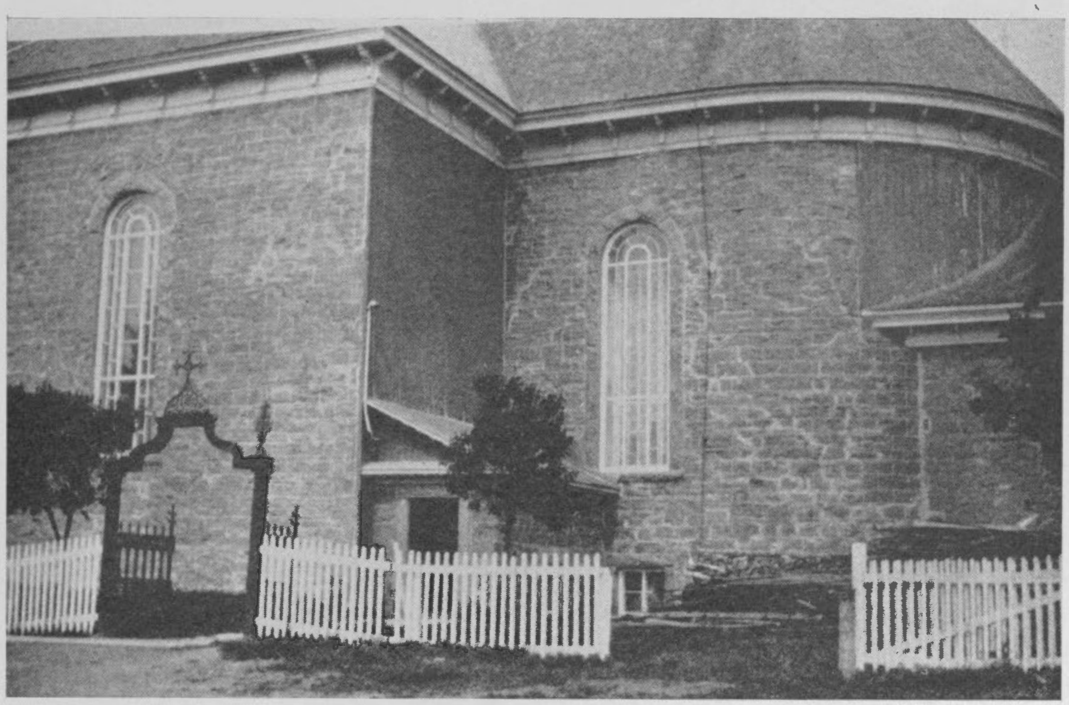

FIG. 6.—Rear of church at St. Pascal (restored)
Photo by J. W. Goldthwait

Quebec—The damage in the city of Quebec was confined to a narrow belt bordering the Saint Charles river. The structures which were chiefly damaged were the Palais Station of the C.P.R. and the grain elevators and shipping sheds which border the Saint Charles.

Palais Station is well built of steel and brick. The earthquake swayed the steel structure, breaking many panes of glass in the skylights. The swinging steel battered the top rows of bricks out of the wall in the north end of the waiting room. These piled on the floor in front of the train bulletin board, but no one was injured.

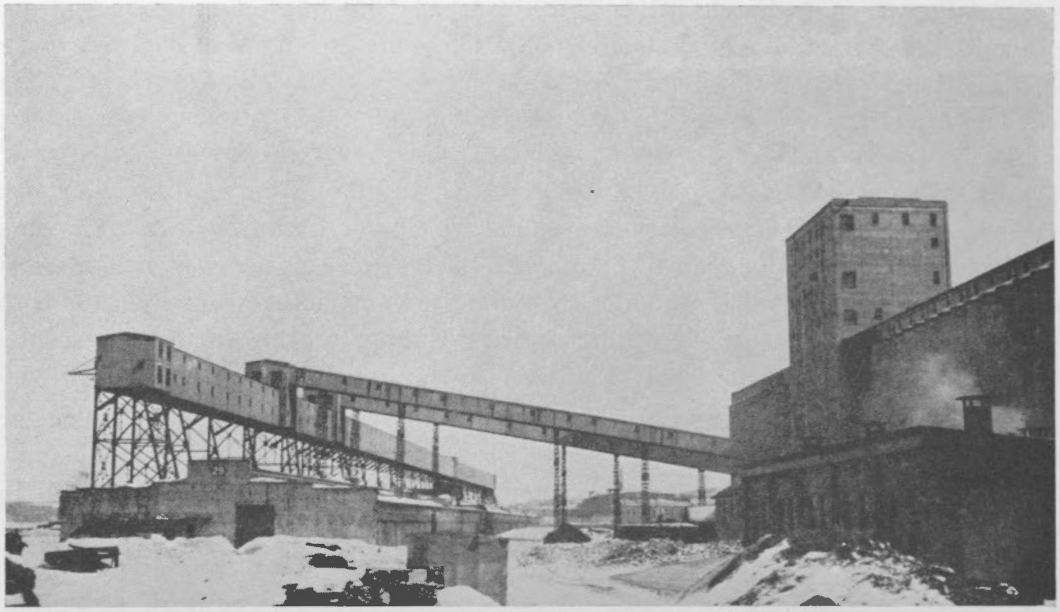

FIG. 7.—Grain elevator and freight sheds at Quebec

The grain elevator and loading sheds are built on made ground on the west bank of the Saint Charles river (*see* fig. 7). To make the ground area required, piles had been driven to a depth of 42 feet along the edge of the river. These piles extended 24 feet above the bottom of the river, being 66 feet over all. The earth required to fill behind the piles was dredged from the river floor. On the land so made a great shed was built, 1,000 feet in length and parallel to the row of piling, but far enough behind it to permit several lines of railway tracks on the water side of the sheds.

The sheds proper are about 30 feet in height. Between the roof of the sheds and the floor of a row of "grain galleries" above, the steel frame stands open. The galleries are themselves about 30 feet in height, making an overall of about 110 feet. The supporting steel is in the form of I-beam columns which are spaced 20 feet apart each way. The sheds are 100 feet wide. The columns along each side are braced by having a 20-foot L-bar carried over from each to its respectively opposite column in the next inner row. The foot of each column rests on its individual cement pier. The galleries are connected to the grain elevator by an overhead coupling at shed 28.

Obviously the structure is very top heavy. At the time of the earthquake the made ground yielded. The galleries lurched toward the river forcing back the foot of each column by about 3 inches (*see* fig. 8), thereby bending the L-braces (*see* fig. 9). Then, the elastic strength of the steel proving sufficient to prevent the structure overturning altogether, the whole swayed back again, this time forcing the foot of each column on the back wall out of its place on its pier. The swaying pulled the overhead coupling several inches away from the warehouse. The sheds are cased with sheet metal but have ceilings of concrete. At the time of the earthquake several sections of this concrete ceiling were thrown down. Fortunately, the sheds were empty at the time of the quake.

The grain elevator is provided with more than a hundred massive, cylindrical, concrete bins about 100 feet high and 16 feet in diameter, with a "workroom" above, which is

200 feet high, 100 feet long and 60 feet wide. The top hundred feet of this section projects beyond the tops of the bins and stands clear, with four stories of floors in it. High in this upper section is a battery of scales for weighing the grain. These are immense affairs, each capable of handling 60 tons of grain. These scales were thrown off their pivots, all falling south. The counterweights, formed of plates of iron about 2 inches thick and 18 inches square, built up into a mass 5 feet high by means of two bolts seven-eighths of an inch in diameter, were swung so violently that the bolts were sheared off and the plates flung to the floor 5 feet below. Four automatic scales, which could not be thrown off pivots, swung to and fro in the steel plate enclosures, banging on the doors until the latter were battered, as if made of lead, by the projecting points of the swaying scales.

The whole upper section of the work room swayed with the heavy machinery so that practically all of the reinforced concrete columns about the outer walls were cracked at the point where the superstructure meets the top of the main building. These were not simple cracks. Some had worked back and forth until great sections of concrete were ground out of the face, several feet long, a foot into the wall, and a foot to eighteen inches wide

FIG. 8.—Shift of foot of steel supporting column of the freight sheds at Quebec

on the face. The reinforcing irons, rods about half an inch in diameter, were in some cases worked out through these cracks. No one was in the building at the time. The noise and the swaying would surely have been terrifying.

Less than half a mile from the elevator and shed stands the Chateau Frontenac, the great Canadian Pacific Railway hotel. It is on the rocky cliff supporting the central part of Quebec. Some persons in this building did not hear the earthquake at all. No one was greatly alarmed by it. The difference between the effects observed at these

Fig. 9.—Bent back brace at freight sheds at Quebec

two spots so close together is due entirely to terrain. The buildings at the harbour are very well constructed. Had they not been they must have been completely wrecked. They were built where the need demanded, beside the river. The soft ground was the cause of the damage rather than proximity to the epicentre.

At the time of the earthquake great icicles hung on the eaves of many buildings in Quebec (*see* fig. 10). Some of these, on the rocky foundation of centre town, were quite undisturbed by the quake. A number of ice statues and arches (*see* fig. 11) are constructed

FIG. 10.—Icicles at Neptune Inn, Quebec

FIG. 11.—Ice arch at Quebec

here and there about this city in the winter. None of these was damaged by the shock. The breaking of chimneys was not at all general, those which yielded being in poor repair, as a rule, and nearly all in the lower sections of the city.

It may be noted in passing that the sheds at the harbour were built in 1917-18. When first built they used to sink about an inch in six months due to the settling of the filled ground, but they had not been sinking appreciably at the time of the earthquake.

Trois Rivières—Damage at this point was not serious. Three cases require special mention. . The Wabasso Cotton Co. plant was damaged because a water tank was supported by steel columns which were tied into the walls of the factory. The swaying of the top-heavy structure filled with water resulted in the wall being cracked The Wayagamack Pulp and Paper Company's plant was damaged to some extent. One of the brick stacks, 250 feet high, had about 25 feet thrown off the top by the earthquake. There was some damage to one of the furnaces also. These plants are both on deep sedimentary deposits resting on clay of unknown depth. Damage was also sustained by the Saint Lawrence Paper Mills, one of their brick stacks being badly shaken by the earthquakes. It was not thrown down and was repaired afterwards without having to be entirely rebuilt.

Shawinigan Falls—The damage at Shawinigan Falls was, in each case, due to one or more of four factors: poor workmanship, shoddy material, insecure terrain, or improper design. A number of brick walls were thrown down in part and one altogether (*see* figs 12 and 13) due in each case to a combination of poor workmanship and insecure terrain. Many stone and brick walls were cracked (though they were well built) due to the buildings being placed on or near the slopes of clay banks. The brick transept wall of Saint Marc church was thrown down (*see* fig. 14). The steel frame of the factory plant of the Aluminum Company acted as a battering ram, under the influence of the earthquake movements. It battered out the top of the gable ends at each of the units.

A report on the damage at Trois Rivières and Shawinigan Falls was made by C. D. Abbott of the Inspection Department of the Associated Factory Mutual Insurance Companies. He places the total damage at both places for factories and private dwellings combined at $17,000. His conclusions may well find place at this point as they sum up concisely the situation in the valley of the Saint Maurice as elsewhere in the region subjected to the earthquake tremors:

"*Conclusions*—1. Deep alluvial deposits such as those at Trois Rivières and high unstable ridges like those at Shawinigan Falls are particularly susceptible to earthquake vibrations. Buildings founded on rock are unlikely to be damaged.

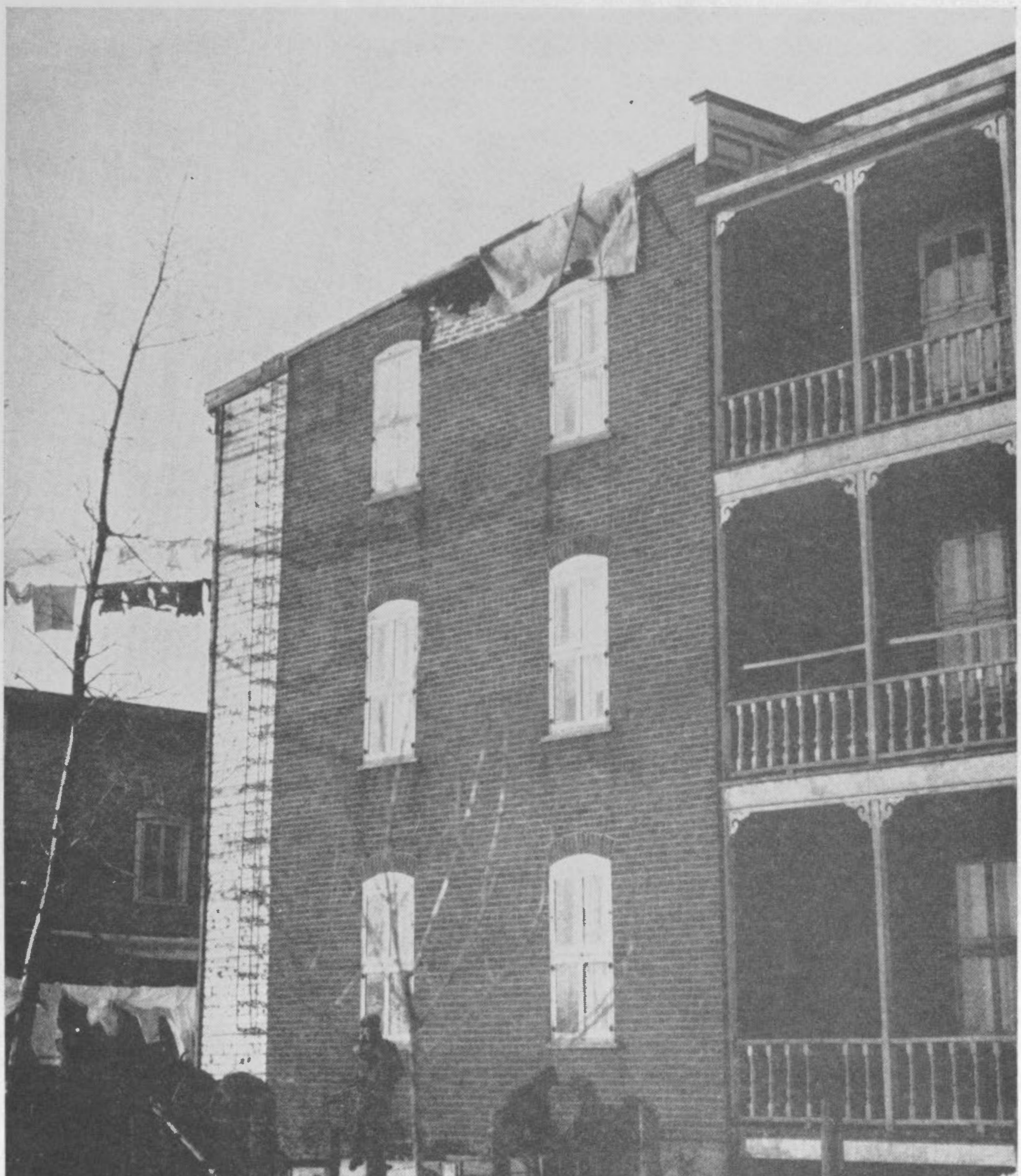

FIG. 12.—Damaged wall at Shawinigan Falls

FIG. 13.—Damaged wall at Shawinigan Falls

"2. Although the instability of foundation soil augmented the earthquake vibrations and was therefore in part responsible for the damage, certain weaknesses or peculiarities of construction were equally influential in causing damage. The maximum intensity of the earthquake at Shawinigan Falls and Trois Rivières is not considered great enough to have damaged properly-designed, well-built, and well-maintained structures.

"3. The Wabasso Cotton Company would have received no injury had it not been for the heavy water load at the top of the stair tower and the difference in the vibration periods of the main building and the tower.

"4. The stack and furnace at the Wayagamack Pulp and Paper Company and the stack at the Saint Lawrence Paper Mills would not have been damaged if the mortar had not been loosened or even eroded from the joints.

"5. The injury to the buildings at the Aluminum Company of Canada was not due to inferior brick work but rather to the large pitched roofs supported on flexible steel frames which swayed longitudinally with a greater amplitude and different period than the gabled ends.

"6. Other structures at Shawinigan Falls were damaged because of obvious weaknesses. The brick walls that fell were of inferior construction, unbraced, thin, and laid in poor mortar.

"7. Unless different parts of buildings are well tied together they are very likely to crack along the intersection at the time of even a light earthquake shock. Plaster on metal lath is more resistant to cracking than plaster on wooden lath.

"8. As shown by all earthquakes a steel frame while exceedingly resistant to damage in itself must be very thoroughly tied into brick walls, otherwise it will pound the walls down because of its greater amplitude of motion.

"9. Heavy tile roofs are very susceptible to earthquake damage and the heavy roof is a menace to the building as a whole."

In closing this section of the report, dealing with the areas of greatest severity, it is well to consider for a moment the probable extent of the damage and loss of life had the industrial plants and their attendant homes for workmen been built in the vicinity of, say, Rivière Ouelle church at the time of the earthquake. Rivière Ouelle church has been rebuilt, as nearly as possible exactly the same as before. It was torn down to the foundation and re-erected with the same stone. Except with a picture of the original church before one, the difference cannot be detected. It will almost certainly have to pass through another such earthquake during its probable life, yet no precautions have been taken to prevent a recurrence of the destruction of 1925, which, fortunately, occurred at a time when there were no worshippers in the building. Will the next earthquake be so happily placed in the day's program? Furthermore, industrial plants are to-day being built within striking distance of this epicentral region, trangressing some or all of the known rules for buildings in such areas. If an earthquake originating in this region can cause $17,000 damage to buildings at a distance of 120 miles, what will be the effect of the next great

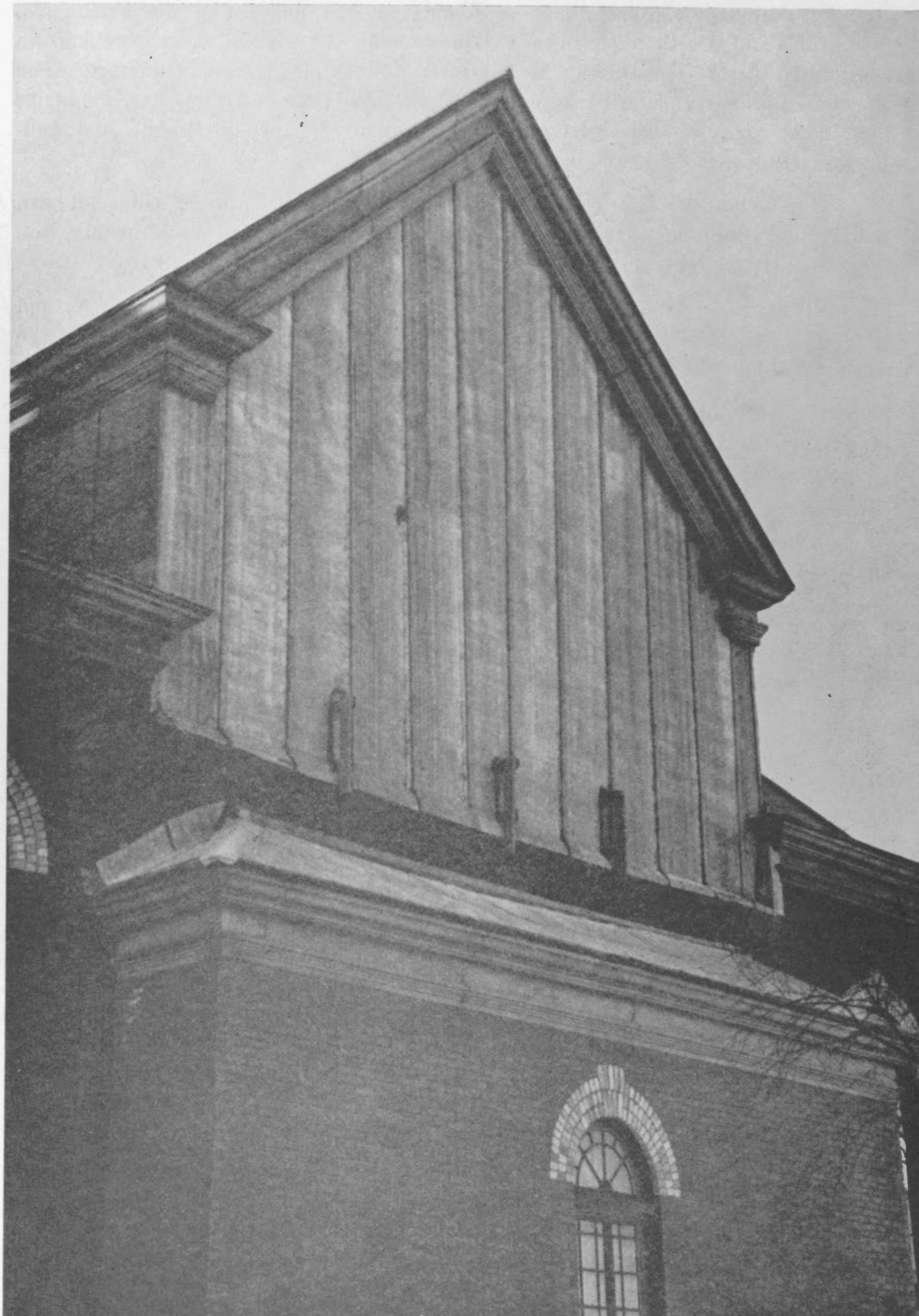

FIG. 14.—Transept wall of Saint Marc's church, Shawinigan Falls

shock on buildings, erected in the interval, within 25 to 50 miles of the centre? As will be shown later, earthquakes are known to have occurred at intervals of about sixty years for the past three centuries and more, their epicentres being, presumably, in about the same position as that of 1925.

(3) *Earth cracks and slumps*

At the time of the earthquake the ground was deeply frozen over the entire epicentral region. The snow covering was deep and had an icy crust. The frozen crust and the frozen earth surface beneath it were generally cracked in the region on the south shore from Sainte Louise to Saint Philippe. The frozen crust was cracked as far east as Gaspé. The following note by the late Dr. John M. Clarke of the State Museum, Albany N.Y., appeared in *Science*, No. 1580, p. 392, April 10, 1925.

"A few days before the earthquake of February 28, there was rain over the snow-covered fields of Gaspé. This froze into a hard crust. The morning after the tremor this crust over the snow fields was found to be cracked in long parallel lines running

FIG. 15.—Cracks in soil at Sainte Anne de la Pocatière

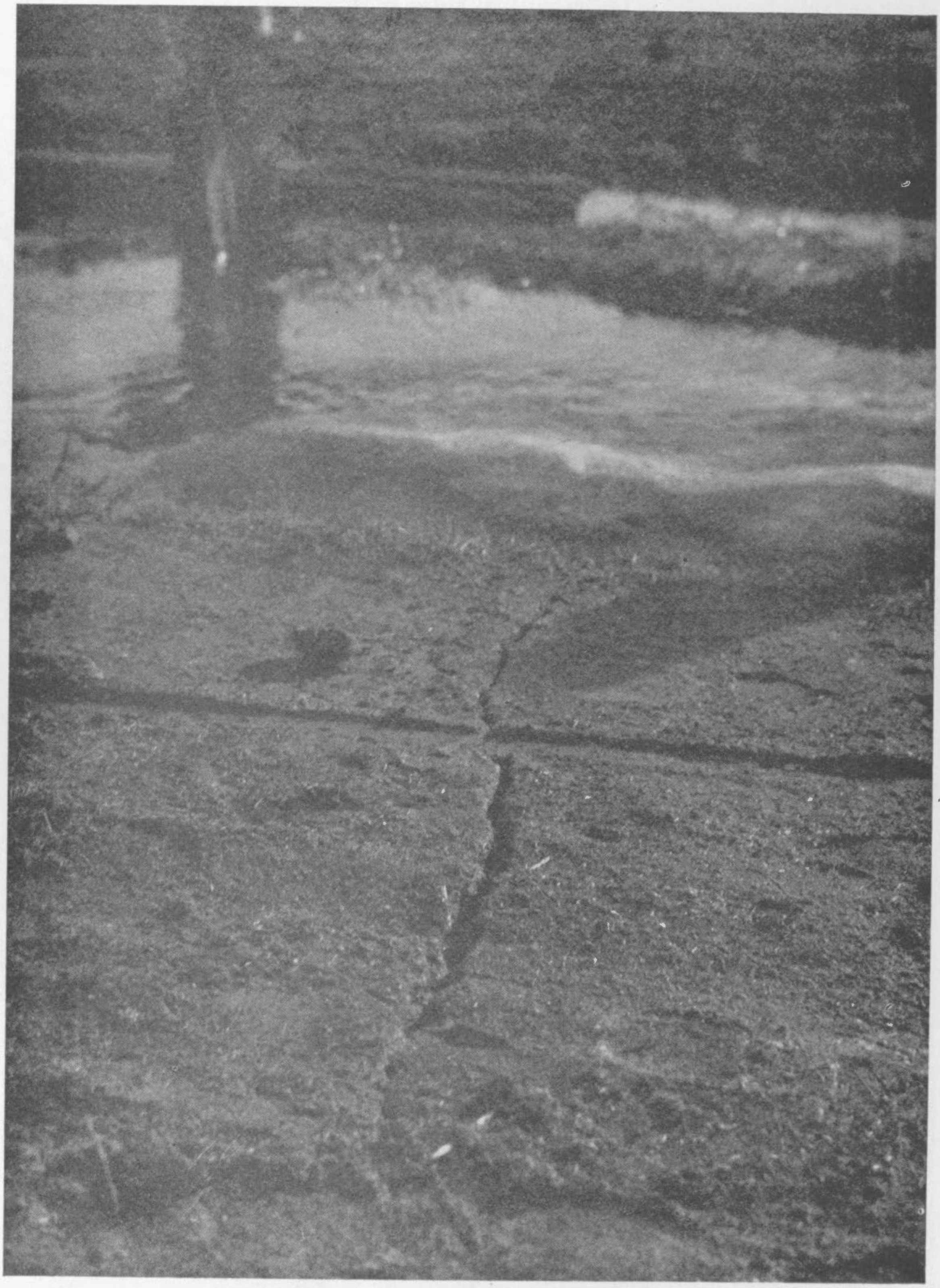

FIG. 16.—Typical crack in the road near Kamouraska

NW-SE, a little E. This observation was reported to me by Mr. F. J. Richmond of Gaspé, a close observer, who adds that when the snow settles naturally, cracks in the crusts will follow the sags of the ground surface. This automatic register of the movment of the earth wave indicates a course at right angles to the directions given, namely NE to SW. The direction of these crust cracks has been verified since, by observations made by lumbermen 40 miles inland from Gaspé."

These snow cracks were not observed on the north shore and were found on the south shore only as far west as Sainte Louise. It is possible that they escaped notice during the visits to those places which were inspected previous to the Rivière Ouelle district. At Sainte Anne de la Pocatière they were very noticeable. They were so well marked that they attracted attention as one passed in a train.

That the cracks in the snow reached to the ground itself was very well verified at Sainte Anne. To the north of the village the land slopes down rapidly to a level plain just above the level of the Saint Lawrence at high tide. This section is very good farm land. Certain cracks in the snow were so well marked that they were noted at the time. Several were inspected shortly after the earthquake. The following spring, when the farmers ploughed the fields, the furrows, one after another, broke as they were being turned, as if cut by a knife. These cuts, as defined furrow by furrow, traced out the mark of the great cracks in the snow at the time of the earthquake.

One particularly well-defined case was observed and photographed just west of the village af Sainte Anne (*see* fig. 15). A field had been in potatoes the summer of 1924 so that the surface was free from weeds. At the time of the earthquake it was, of course, deeply covered with snow. After the snow had melted, six or seven weeks after the earthquake, the marks of the cracks were well-defined in the moist earth surface. These were in the form of a grid, the cracks being approximately at right angles and about 100 feet apart each way.

The roads, from near Sainte Anne de la Pocatière to Kamouraska, were broken at intervals, the cracks extending, apparently to the bottom of the road embankment (*see* fig. 16). These cracks persisted until after the snow had melted. Many of them were photographed. It was noticed that the cracks were much better defined and were at more regular intervals on roads running north-south than on others at right angles. On one road, running from Saint Pascal to Kamouraska, an attempt was made to determine whether there might be any regularity in the breaks. The observer walked the entire length of this north-south road. It was found that the cracks were about 30 paces (approximately 100 feet) apart and that there was undoubted regularity in this flat-lying road, traversing an alluvial plain.

It was reported that springs opened in the fields near this road at the time of the earthquake. A row of fence posts was also reported to have been broken off at the ground line but the report was not followed up. A horse is said to have been mired by stepping into a concealed crack when working on the land in this vicinity the following spring.

The largest earth cracks reported were inspected. One was between Saint Urbain and Baie Saint Paul and has been referred to on page 371. A second was near the church of Rivière Ouelle parish and has been described on page 377 (*see* fig. 17). The third was at Saint Pacôme. It has been mentioned on page 373, but further details may be given. It

FIG. 17.—Slump crack in ground near Rivière Ouelle church

was visited within a couple of weeks after the earthquake. It was along the edge of a hill where the valley of Rivière Ouelle slopes up to a rocky ledge. The crack was well defined for a distance of more than 100 yards. After the snow melted it was still well defined. After the lapse of six weeks or so, a stick could be put in it freely to a depth of about 16 inches. It was, of course, very much deeper when first opened in the deeply frozen soil.

In every case the cracks in earth occurred where the water table was only a foot or two below the surface, in deep alluvial soil, where the clay deposits lay against the steep slopes of outcropping rock ledges, or where there was a sharp difference in level in the clay, as at Rivière Ouelle church, where the section of frozen ground, about 33 feet wide and some 150 feet long, slid toward the river, which has cut down a channel about 15 feet deep at this point. None of the cracks could be considered as defining the position of a shifted fault in the underlying rock.

(4) *Effects on wells and springs*

Many reports were received as to the effects on wells and springs, but in no case was it found possible to visit the places reported *after* the information had been obtained. In one or two cases the region had previously been visited without any mention being made by those interviewed of the effects on wells or springs in the neighbourhood.

A report was received of one well in Rivière du Loup which dried up at the time of the earthquake and of another which had been "hard" water before the earthquake but which was found to have "soft" water in it afterwards.

A spring was said to have opened in the field near Kamouraska at the time of the earthquake.

The water of a well at Saint Denis, not far from the Saint Lawrence, which is tide water at this point, was reputed to have been excellent before the earthquake but to have turned "fishy" at the time of the shock, and so continued.

At Saint Onésime to the south of Sainte Anne de la Pocatière, a well is reported to have dried up and another to have opened, one of these being at the presbytery.

It is quite to be expected that wells and springs in these regions should have been affected by the earthquake. None of these wells is, presumably, of very great depth, as the water table at all points is reported as being less than 15 feet from the surface. The ground was frozen to a depth of perhaps 5 to 6 feet, as it had been a very cold winter. The comparatively shallow subterranean water channels might well have been changed by the earthquake shock. As in the case of the earth cracks, the effects on the wells cannot be considered as indicating the exact location of the shifted fault or faults.

(5) *Effects on chimneys*

The effect on chimneys in the immediate epicentral district has been sketched in subsection (2) above. Practically every chimney was thrown down in the district within 5 miles in every direction of Rivière Ouelle church. This includes the parishes of Sainte Anne de la Pocatière, Saint Pacôme, Saint Philippe, and Saint Denis. The destruction of chimneys was quite general at Pointe au Pic and at Malbaie on the north shore, but was not universal. At Baie Saint Paul and at Les Eboulements many chimneys were overthrown. As to the rest of the area affected, it may be said that if chimneys fell they were in poor repair or the houses on which they were built stood on deep soil, possibly on the bank of a stream or on a slope of some sort.

The twisting of chimneys to which reference has been made on page 372 was common at Pointe au Pic and at Malbaie on the north shore, and at Sainte Anne de la Pocatière on the south shore.

At Saint Pacôme one chimney came off in a block, having broken loose at the house roof. It was said to have been thrown clear of the roof. No marks of it were to be seen on the shingles but it is probable that the roof was covered with snow at the time of the earthquake and that this protected the shingles as the chimney rolled off.

In general it serves little purpose to record the direction of fall of a chimney. The fact that the interaction of the brick and the frame construction (for most ofthe houses in the district were of frame) probably causes the first break in a well-built chimney, makes the orientation of the house a large factor in determining the direction of fall. Again, many chimneys are in poor repair. An hour's observation of chimneys along any route during a country drive will establish the fact that repairs are frequently in order. This is even more true in towns and cities, in the poorer residential sections, and also in some of the best.

(6) *Opening of doors*

Certain typical stories are told to every investigator of earthquake in the field. One of these typical stories is to the effect that locked, latched, or bolted doors are opened by the earthquake. It seems worth while to record two such cases which were reported first hand. It is impossible to escape the feeling that the doors may have been thoughtlessly opened in the confusion following the shock, but that does not necessarily follow. Frame structures can be warped out of shape to a remarkable degree by settling alone or by injudicious application of jacks in lifting them. The earthquake performs the function of shifting the building in different directions in rapid sequence. It is quite probable that both the cases here reported really happened substantially as outlined.

The first is at the station at Saint Pacôme, the story of which was given on page 374. There is no doubt that this loosely-built frame structure was greatly racked by the extraordinarily severe movements. An outer door is provided with a large latch of the type common in country houses and in barns—an iron latch hinged at one end on a screw, lifted by a hooked iron lever in the side of the latch itself and by a projecting thumb plate on the other side of the door. The latch fits down into a notched iron plate on the door jamb. To prevent the latch being lifted a wooden plug is pushed in above the latch and inside the guide which keeps the latch close to the door. This plug was set in place shortly before the earthquake. After the quake, the heavy door stood open, the plug still being in place above the latch. The notch out of which the latch had to lift in order that the door might open was about a quarter of an inch deep. An illustration showing the sturdy nature of the door and the latch and plug is given in fig. 18.

The second case is one observed at the manoir house near Malbaie. A workshop or tool house had been very well constructed of frame. Across one end were several pairs of windows opening inward on hinges. These windows were held shut in each case by a

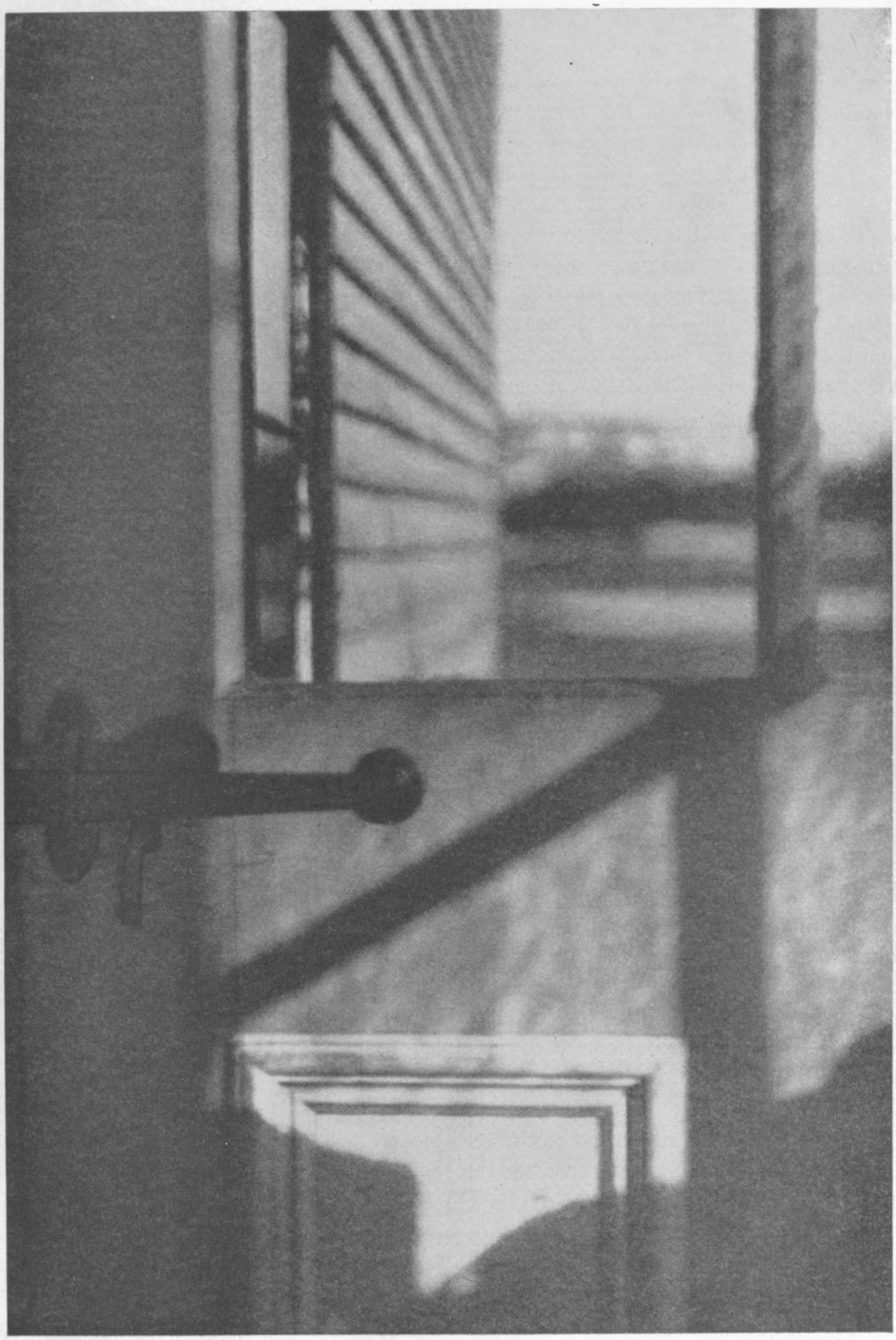

Fig. 18.—Door latch at Saint Pacôme station

wooden "button" set by a screw in the central bar of the window frame. The windows were all closed at the time of the earthquake. The following morning they were found open with the button still crosswise preventing their closing. These windows were examined. The workmanship was of the very best, the buttons were friction tight, the glass of the windows was not broken.

Undoubtedly these stories of doors and windows opening at the time of an earthquake are often authentic. The established fact serves to show the great flexibility of frame buildings and their value in an earthquake region. It may safely be said that *in the case of any earthquake which we may reasonably expect to experience, no well constructed frame building in any part of the province of Quebec, on any kind of ground which will not actually slide laterally with the house on it, is in danger of collapse.* The dangers to be guarded against are three. In the first place the chimney should be so constructed that it is altogether outside the house or that its fall inside will be within a specially constructed frame-covered space. Secondly, at the time of the earthquake the first thought should be to extinguish all fires. A third precaution is worth noting: Statues, pictures, crucifixes, ornaments, etc. should be so placed that they cannot fall on a bed. At least two cases were reported where children were cut by objects falling from above their beds.

(7) *Earthquake sounds*

The reports on earthquake sounds are interesting and significant. Where no sound precedes the shock and where the latter arrives as "a sharp jolt from beneath" it may safely be inferred that the epicentre is very close at hand. Where the sound is heard for some time before the jolt arrives it indicates that the epicentre is distant. It is doubtful whether the direction from which an earthquake wave is approaching can be determined from the sound. Preconceived ideas play a large part in a determination of direction. Sounds are heard often through open windows which mask the direction of approach. Reflection and refraction play a part. Rickety or frost bound structures to the south, say, may be rattling, before anything is heard from the north, though the tremors may be arriving from the north. The reports of earthquake sounds were found to be useless for the purpose of determining direction.

It is interesting to note the similes used by the reporters in their descriptions of the sound. Their past experiences are reflected therein. One will report the sound as simply "like thunder". Another states that it was "as if heavy Clydesdale horses were drawing a large rumbling waggon". One man hears it as "a roaring noise like a gasoline blow torch". A forest ranger thought it resembled "a great wind storm starting". Others considered it "like a fire in the chimney," "like a whirlwind," "like a train".

At Pointe au Pic and at Sainte Anne de la Pocatière the aftershocks were described as sounding "like the ripping of cloth," or "like a crack going across the ice in the bay". These are sounds not generally reported but were observed in these two villages on opposite sides of the Saint Lawrence by many, including the writer.

One interesting case was personally reported to the writer by a priest at Chicoutimi. He was in a room with his back to the wall toward the northwest. He thus faced a crucifix on the opposite wall toward the southeast. He heard the sounds but felt nothing until after he saw the crucifix move. This report was given before it was known that the epicentre really does lie south-southeast of Chicoutimi.

Trainmen, riding on an engine running to Malbaie at the time of the main shock, and also at 9:32 p.m. E.S.T., March 6, when one of the aftershocks was experienced, report that they heard the earthquake coming above the noise of the engine.

(8) *Effects on animals*

The effects on animals are believed to be closely associated with earthquake sounds. They seem to be able to hear something before anyone about them has noticed it. The following notes are recorded. At Maitland, N.S., rats ran up out of the cellar at the time of the earthquake. At Shelburne, N.S., hens were much excited. At Gaspé, Que., a watchdog was reported as frightened. Generally, throughout the epicentral region, the effect on the animals was lost in the effect on the people who had little opportunity to make any observations of that nature. This earthquake is rather remarkable in that the above are the only reports received of this nature.

(9) *Deaths reported as due to the earthquake*

The following deaths were reported as due to nervous shock caused by the earthquake:

Mrs. Alphonse Auger, of Quebec, fainted at the time of the earthquake and did not recover consciousness for some time. Her condition became worse and she died two days later. She was about to give birth to her first child.

Mrs. Eugène Bureau of Sainte Anne de la Pérade fell unconscious during the earthquake and died before medical help could be summoned.

Mrs. Albert Roy of Chicoutimi died of shock during the earthquake.

It was reported that one death occurred at Tadoussac but this is not established. It is possible that the victim was a resident of a nearby village.

According to a report in the Quebec Telegraph of March 3, 1925, Mrs. Oriel Smith (29) of Newark, Ohio, died as a result of nervous shock during the earthquake.

It was also reported that a man in Brooklyn was frightened by the tremors and fell off a station platform in front of a train and was killed!

The first three of these reports are well established but none indicates a death due to the mechanical effects of the earthquake. Every report reaching this office has been included above. It is most remarkable that with all the fallen chimneys and statues, not to mention the throwing down of walls near Rivière Ouelle and the falling bricks at Palais Station, Quebec, etc. no one was injured seriously as a direct result of the earthquake vibrations. It may also be mentioned again in passing that no fires resulted from overturned stoves and lamps.

(10) *Electrical phenomena*

Reports of electrical phenomena are always circulated in the case of a large earthquake. It is difficult to establish the truth of such reports. "Dead" telephone lines running into Baie Saint Paul through Saint Urbain were said to have emitted sparks and to have given operators electric shocks. At Chicoutimi several persons reported seeing lightning and hearing thunder during the earthquake. Woodsmen from the country near Port Alfred also reported thunder and lightning.

The report of a strange light to the west of Saint Denis has been referred to on page 14. The parish priest states that it was due to a partially obscured new moon which was setting at the time.

In a paper entitled "Destructive Earthquake in Sagami Bay," (Japanese Journal of Astronomy and Geophysics, Vol. 2, No. 4, 173-192, Tokyo, 1925) the author, Katsuyoshi Shiratori, comments on these electrical phenomena as applied to the earthquake he is considering—the Tokyo earthquake of September 1, 1923. He writes:

"It is said that, in the case of some earthquakes, telegraph operators often feel electric shocks, which is considered as a result of the change in the contact resistance of the electric earth-plate caused by the earthquake. Fortunately, we have for some time been observing the variation of earth-potential, by a zero method, using a potentiometer.

"Three electrodes (diameter 2 centimetres) of copper, galvanized with zinc, were arranged as shown (as at the three corners of a square one side of which is oriented parallel to the meridian, one electrode being at the southeast corner and the other two at adjacent corners; the centre electrode is labelled both E and S, the other two being, respectively, N and W). The depth of the electrode is 1 metre under ground and the distance between E and W, or E and N is ten metres; the direction of E to W is E-W and that E to N is N-S. If the magnetic flux varies in some way in the loops of the leading wires from the electrodes to the potentiometer, corresponding electromotive force must be induced; but, though we have examined this effect by making other loops parallel to those, it was too small to be observed by the potentiometer.

In fact, however, it is observed that the earth-potential shows abnormally large variation during earthquakes especially in the case of near earthquakes. Its variation during the great Sagami Bay earthquake is shown in an appended figure in which the courses of the potential difference in the three directions NS, NW, and EW are given. On October, 9, 1923, ($20^h\ 22^m\ 55^s$) a comparatively strong near earthquake at Tono, Iwate Prefecture (about 120 km. distant from Sendai), in which case the potential difference in NS and NW was affected while that in EW was not, as shown in the appended figure. There was another near earthquake with sudden shocks in the sea of Nakamura, Fukushima Prefecture (about 60 km. distant from Sendai), at $20^h\ 1^m\ 26^s$, October 31, 1923, in which case NS and EW were influenced, but NW component remained constant as shown in an appended figure." (The values of the potentials are given in following tables. The tables show the variations in potential in micro-volts for two- to four-hour intervals during the three earthquakes mentioned.) The paper continues:

"From these results it may be safely concluded that such potential variations depend on the direction of the epicentres of earthquakes. Sagami Bay is in the direction of SSW from Sendai, Tono is NNE, and the epicentre in the sea off Nakamura is ESE."

The tables show differences in potential of less than a fifth of a volt at the maximum. It is to be remembered, however, that the distances to the epicentre are as follows: for the Sagami Bay earthquake 380 kilometres; for the Tono earthquake 120 kilometres;

and for the Nakamura earthquake 60 kilometres. Baie Saint Paul is only about 25 miles from the epicentre. It is thus possible that potential differences *might* have been set up sufficient to cause the electric shocks, but the writer is very skeptical nevertheless.

A careful examination of the three cases presented by Shiratori fails to reveal any definite law as to the direction to the epicentre for a given potential effect. In the case at Baie Saint Paul, the line reported as sparking runs practically due north from that town, while the epicentre is almost exactly due east.

It is said that similar electrical phenomena were observed at Baie Saint Paul at the time of the earthquake of 1870. (It has not been possible to learn definitely that the lines were even in existence so long ago.) It may be noted, in passing, that the accounts of the earthquakes of 1663 speak of lightning and thunder and of strange lights in the sky.

It would be most interesting and valuable if further study would evolve some indication of the direction to the epicentre in potential variations. Such variations, if consistent, would permit a simple pre-arrangement for determining the position of the epicentre of a local earthquake by intersecting asimuth lines. Enquiry reveals the fact that at the time of the Grand Banks earthquake of November 18, 1929, the cables which did not break but which crossed the ocean bed to the north of the epicentre did not show a surge which was discernible in the instrument records. These normally show load conditions which vary through rather wide limits. Nothing registered which would be defined as beyond normal variations.

(11) *Reports proved erroneous*

(*a*) It was widely reported that a fine new stone church at Saint Hilarion, Que., was completely wrecked by the earthquake. This story was quite without foundation. It is possible that the damage at the church at Saint Urbain, which is not far distant, may have led to the report.

(*b*) The accounts of damage to the church at Baie Saint Paul were grossly exaggerated.

(*c*) The fire at Saint Félicien and that at Hébertville, reported as having been caused by the earthquake, were found to have been burning at least three hours before the tremors began. The situation at Saint Félicien may be put on record as a typical example of the terrifying events of that night for many localities. The houses are all of wood. The night was snappily cold. Under these circumstances the houses crack and creak in a startling fashion (as was experienced by the writer in approaching Saint Félicien on foot at night about ten days after the earthquake). About six o'clock in the evening of February 28, 1925, fire broke out in the village. This is a serious matter where structures are of wood and most of the water is frozen. There was real danger that the entire village might burn. After a strenuous three hours of fire fighting the house was a pile of glowing embers; the villagers were resting. Then the earthquake started. The houses, which had cracked at intervals before, simply volleyed in the tremors. The general impression seems to have been that the end of the world was at hand. It may safely be stated that the most sophisticated will find it difficult to gauge what their own reaction would have been to the unusual and terrifying circumstances.

(*d*) It was widely reported that, at the time of the earthquake, a long-distance conversation was under way between Chicoutimi and Malbaie and that the earthquake was felt at one place before it was felt at the other. This would have been important, if true. Thus every attempt was made to locate details regarding a long-distance connection operating at the instant of the quake, or a long-distance telegraph communication under way at that time. The manager of the telephone company at Malbaie consulted his records and proved that no such connection had been in operation. A similar service was rendered by the managers of the companies at Rivière du Loup and at Chicoutimi. No trace of a telegraph message being put through at that time could be found. Every case reported as to persons concerned was traced to its source and invariably found to be without foundation.

(*e*) The level of the Saint Lawrence did not change, up or down, at the time of the shock. Each of these results was currently reported. The tide gauge records conclusively prove these reports to be without the slightest foundation. A much more detailed story was in circulation regarding the level of lake Timiskaming. It was reported that the level of this lake "rose 4 inches at the time of the earthquake, then shortly afterwards sank 8 inches, and finally after some days regained its normal level". It was not considered worth while investigating this widely circulated report.

(*f*) The report of the shift of a house on its foundations at Pointe au Pic has been mentioned (page 371) as having been found untrue. The story of the strange fires at Saint Denis has been explained (page 377).

(*g*) It was commonly reported that a great landslide had been caused at Shawinigan Falls. The slide to which reference was made occurred during the previous autumn in the hills to the west of that city.

(*h*) The epicentre locations as made by various agencies for press purposes are interesting. As usual, the "Fundian Fault" was a convenient pigeon-hole for the hurried disposal of the epicentre position. But other "locations" were made as "near New York city—possibly in the direction of Washington," and "near the Great Lakes".

(*i*) The press reported a prediction that a second great earthquake would be experienced "in a month". The writer knows of actual cases where people within the epicentral district sat up the night of March 28, and then being afraid of a confusion of "months", since February was so short, did not breathe freely for another three days. It is a serious matter to publish such reports. The credulity of those in close contact with an earthquake is unduly sharpened and their worry is quite real.

(*j*)) As has been mentioned (page 368), the early determination of the epicentre of this earthquake by this Division was reported as "either in the bed of the Saint Lawrence near Rivière Ouelle, or north of the river about 30 miles, near the eastern boundary of the Laurentides Park." Later evidence justifies the abandoning of the second alternative, which was at first considered the more probable.

(12) *Extraordinary reports received*

The following reports may possibly have been true but it was impossible to verify or to disprove them. They are interesting possibilities and are listed only as such.

At Saint Denis, a hair net hung about a foot above a dressing table. Some hair pins lying below it were said to have been projected up to the net and to have been found caught therein after the earthquake.

The reports regarding the opening of the door at Saint Pacôme station and of the windows at the manoir near Malbaie have been outlined on page 394. These reports rightly find record here.

The story of the statue being projected upward through the ring of lights, as mentioned on page 379, is another case which might better, perhaps, have been listed in the subsection preceding.

A monument in the cemetery near Rivière Ouelle church was first thought to have been projected vertically upward off the iron pins which held it oriented on its foundation. A visit paid to this cemetery after the stone was again in place permitted a few experimental swayings of the stone by hand. It is possible that it climbed the pins sufficiently to fall off over them.

At Baie Saint Paul a bin of oats was reported as having been shaken in such a manner that "all the heavy ends pointed in one direction". Experiment with a few oats will show that this story is not as improbable as at first appears. It would be interesting to try the experiment with a large bin. Presumably only the surface oats would be oriented and only a percentage of those, but some indication of a general tendency might be expected. The direction of the heavy ends was reported to be northwest.

II. LOCATION OF EPICENTRE BY GROUND SURVEY

(1) *Trips undertaken in course of survey*

The following visits have been made into the disturbed areas:

(*a*) March 5 to March 21, 1925: To Malbaie, Pointe-au-Pic, Baie Saint Paul, Saint Urbain, Quebec, lake Saint John region, Chicoutimi, Ha! Ha! Bay, Lévis, Rivière Ouelle, Saint Pacôme, Sainte Anne de la Pocatière, Rivière du Loup, Trois Pistoles, and Shawinigan Falls.

(*b*) April 2 to April 17, 1925: To Sainte Anne de la Pocatière, Sainte Louise, Rivière du Loup, Notre Dame du Lac, Edmundston, Saint Pascal, Kamouraska, Saint Philippe de Néri, Saint Denis, Mount Carmel, Rivière Ouelle, and Saint Pacôme.

(*c*) July 21 to August 7, 1925: To Sainte Anne de la Pocatière and vicinity, including Rivière Ouelle and Saint Pacôme.

(*d*) May 27, to June 7, 1926: To Shawinigan Falls and to Saint Joachim, on north shore near Baie Saint Paul.

(*e*) June 21, to June 24, 1926: To Saint Joachim region.

(*f*) July 14 to July 24, 1926: A trip in company with Dr. J. W. Goldthwait, to Shawinigan Falls, thence along the north shore of the Saint Lawrence to Quebec and Saint Joachim, up the Sainte Anne river to Seven Falls, and around the island of Orleans, followed by a visit of several days duration to the south shore, most of the time being spent between Sainte Anne de la Pocatière and Kamouraska.

Besides the above visits to the epicentral region many trips have been made to Shawinigan Falls and to the region just west of Baie Saint Paul. These visits afforded opportunity to clear up points raised by a study of the data of this earthquake. Only the first two of the above trips were undertaken primarily for the purpose of investigating the earthquake of February 28, 1925.

(2) *Evidence of swinging suspensions*

It was first thought that an azimuth to the epicentre was defined by the plane of swing of a hanging suspension. The conflicting results obtained soon showed that some care must be exercised in selecting the evidence to be admitted. For example, some swinging objects were not observed until some minutes (in one case about fourteen hours) after the shock. The plane of swing could not be relied on for any length of time for several obvious reasons Again, some suspensions were much more free to swing in one plane than in another.

A few cases of carefully observed directions of swing may be recorded. At Trois Pistoles, the chandeliers in the hotel were observed to swing in a plane which was approximately eastwest.

At Chicoutimi a house set with its long axis from southeast to northwest had pictures on the short wall thrown off while those on the long wall were merely canted out of position, indicating a movement southeast to northwest.

Clocks in jewellers' shops were started in motion and in other cases stopped by the oscillations. The evidence was useless for defining direction. Sometimes the clock seemed to have been stopped by having the pendulum bumped against the back of the case; at other times it seemed to have been stopped by being swung out of phase with its pendulum.

An interesting case of swinging was reported by a most careful and accurate observer at Rivière du Loup. Entering the Church of Saint Patrick for mass at 11·30 Sunday morning, it was noted that the great chandeliers were swinging with an amplitude of at least 3 inches. One defined a plane which did *not* point toward the epicentre. The other was swinging in a circle. Either of these results was, of course, to be expected in the event of the swings continuing for such a long time. The chandeliers are very heavy and long.

(3) *Evidence of shifted masses*

In the vicinity of the epicentre the first motion of an earthquake may be expected to be up, or down, or nearly so. As the distance is increased one may expect to have the azimuth from observation point to epicentre defined by the line of shift of displaced objects. Care must be taken to eliminate all cases where the tendency to slippage is greater in one azimuth than another. Even with this precaution taken, it may be said that azimuths were very indefinitely indicated by the shift of objects at a distance of 15 miles or more from the epicentre.

At Saint Pacôme, objects generally shifted south or north, the first motion being south, indicating a movement toward the north. (At Saint Pacôme station, however, the stoves shifted east.)

At Sainte Louise, a heavy stove in the station moved south; statues in the church fell toward the southwest.

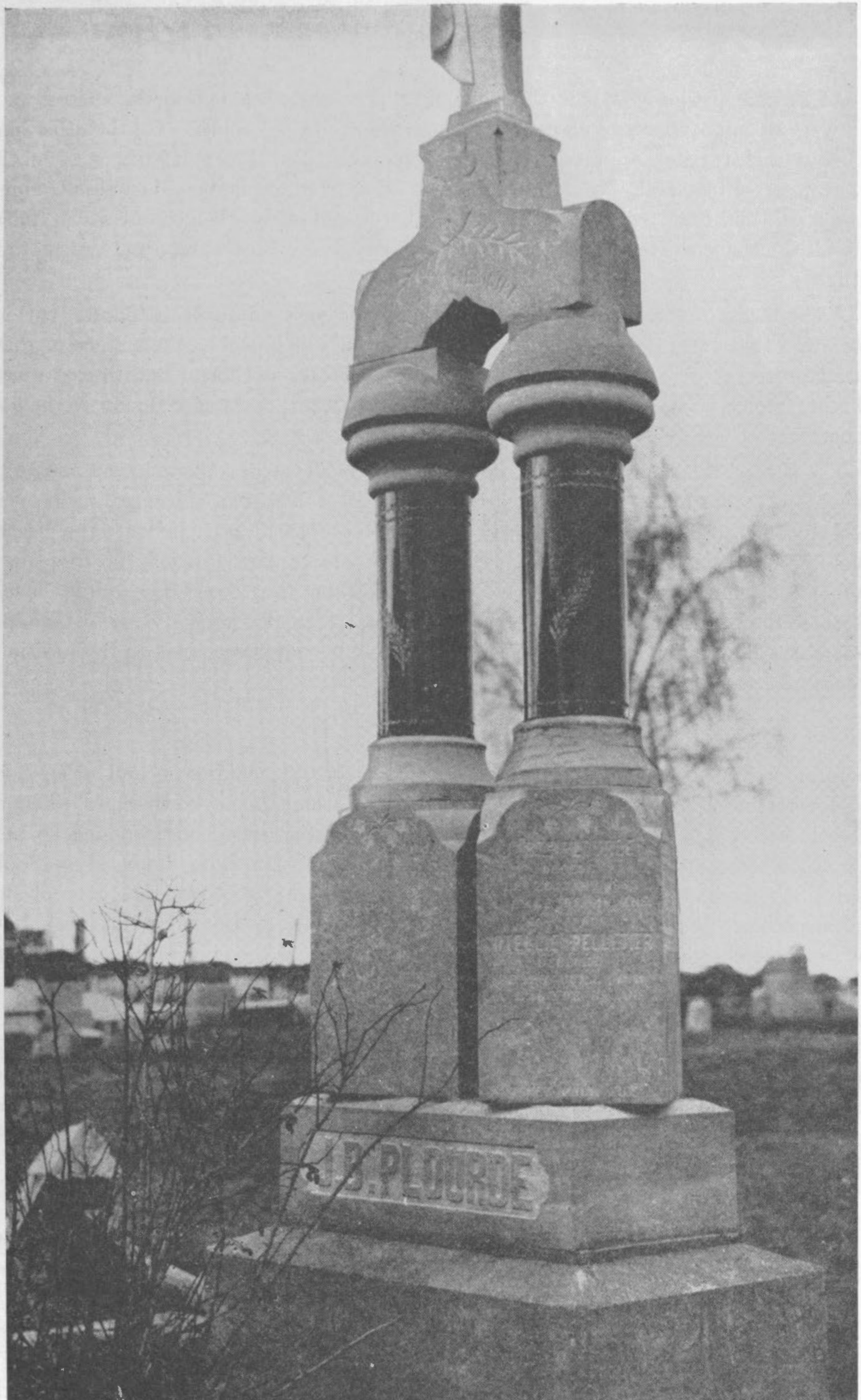

FIG. 19.—Rotated Monument at Rivière Ouelle Cemetery

At Pointe au Pic, bottles in the front of an east-west shelf fell north. Those at the back were struck by the wall at the back of the shelf and fell south. On the other hand, the heavy cash register, apparently free to move in one direction as readily as in another, moved west. In general, objects in one store at Pointe au Pic indicated earth movements to the south and east. A shelf in a buffet which rested on two ledges but which did not quite fill the space shifted to the north and dropped down, indicating a movement to the south.

A summary of the observations on lines of shift may be given as follows, with the reservation that exceptions were often found, most of which could be explained as due to natural slopes, etc. The movement was to the southeast at Chicoutimi, to east or west at Trois Pistoles, to the west at Tadoussac, to the northwest at Rivière Ouelle, to the north or northeast at Sainte Louise.

The observations indicate that it would be very much worth while to have some form of seismoscope set up under definite conditions at many points in an epicentral region which would, by the fall of a column or the direction of roll of a ball, etc., indicate the direction of the first sharp movement. Such seismoscopes could be placed in solid positions in the basements of churches and schools or other places where they could be carefully levelled and where they would not be liable to be disturbed. (See also page 408 for further specifications.) They might be expected to furnish valuable information as to the position of an epicentre.

(4) *Evidence of rotations*

Monuments in cemeteries, objects standing on tables, chimneys, and other heavy masses were, in many cases, rotated by the earthquake, some in a clockwise and others in a contraclockwise direction (*see* figs. 19, 20, 21). Investigation soon provided so many examples of rotation in a common direction in certain areas that it could not be overlooked in spite of the plausible explanation that irregularities of contact on the plane of shift, or tilting of that plane might be the cause of the rotations. Although it was not believed that the data obtained would be of much value in locating the epicentre, some care was taken to record all observations of rotation. It is desirable that this report should be as complete as possible, but it seems needless to repeat at this point the observations for rotation. These were sketched in some considerable detail in the paper on "Rotation Effects of the Saint Lawrence Earthquake", as indicated in No. 4, on page 367 of this report. Especially does it seem useless to repeat the account of this phase of the earthquake phenomena since it has no particular hearing on the final conclusions as to the position and nature of the epicentre. Accordingly, we may rest content with a tabulation of the summary outlined on the last page of the above report, which runs as follows:

(*a*) The rotations do not give any indication of location other than the general one that they occur only relatively close to the epicentre.

(*b*) They are greatly affected by depth of soil; the deeper the soil the greater the rotation for any given distance from the epicentre.

(*c*) Generally speaking, the rotations north of the Saint Lawrence river are clockwise; those south of that river are contra-clockwise.

Fig. 20.—Rotated monument at Rivière Ouelle Cemetery

Fig. 21.—Monument shown in Fig. 20 shown here restored
Photo by J. W. Goldthwait

(*d*) The number of observations on the north shore was limited, due to the fact that rotation effects were not thought of as a special line of study until after leaving the north shore for the south on the first trip of inspection. Also the places at which observations could be made were fewer on the north shore. There are, however, practically no observed exceptions to the clockwise rule on that shore.

(*e*) There are a considerable number of exceptions to the contra-clockwise rule on the south shore, especially at Sainte Anne de la Pocatière.

(*f*) Rotations are evidently affected by the slope of the graveyard and by tree roots near individual monuments.

(*g*) No reasonable theory connecting all the observed phenomena has been deduced.

(5) *Evidence of fallen objects*

The evidence of fallen objects is somewhat better than that given by the shift of heavy bodies or by their rotations. In some cases at least it is impossible to avoid the conclusion that the bodies lie in positions where they were thrown by the first sharp impact. The stoves at the station at Saint Pacôme all moved east (page 373), one of them breaking off and rolling to the east. Moreover they left the trace of their movements in marks on the floor. The new and well-placed monuments at the latest cemetery at Rivière Ouelle church all fell to the southeast (*see* fig. 5). One may not doubt that these monuments show the direction of the first sharp jar, especially when we learn that the shock arrived without warning at that place and that the first "bump" was devastating. The difficulty about accepting in general the direction of fall as evidence of the first

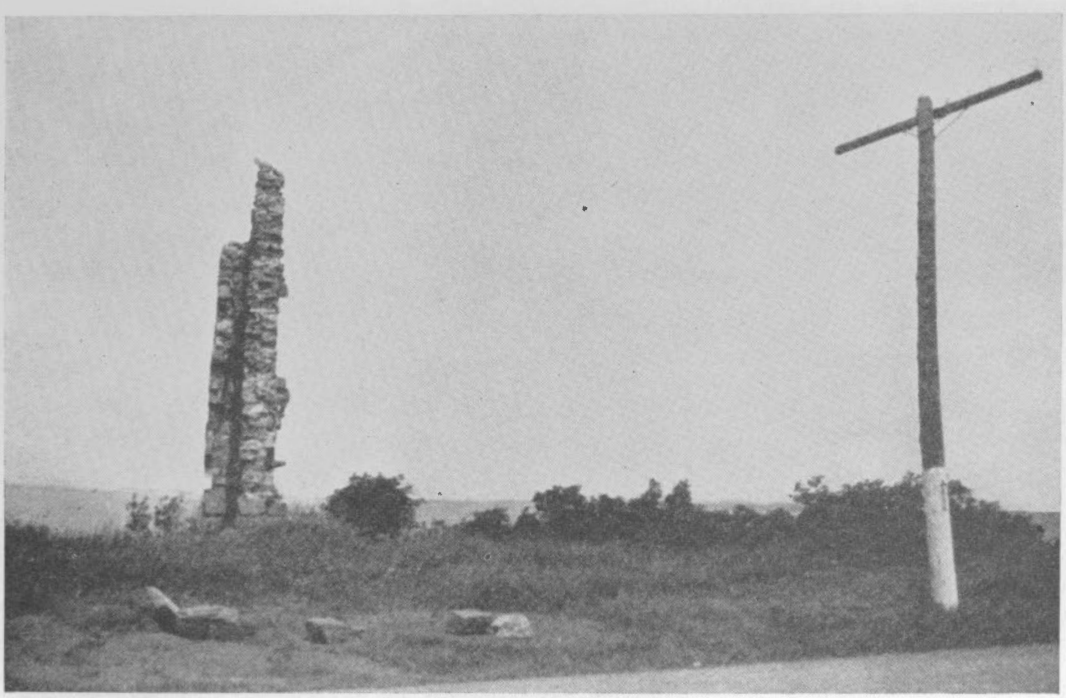

FIG. 22.—Isolated chimney near Montmagny
Photo by J. W. Goldthwait

movement is, of course, that the object may be rocked by a succession of tremors. Thus the final thrust which determines the lie of the fall may be a comparatively slight one, arriving at the moment when the object is almost out of balance and so combining with the sway that overturning results.

In arranging seismoscopes for use in epicentral regions as suggested on page 404, it would be best to provide that the object would be displaced only by the first tremor of a given minimum intensity; that it could not oscillate before that intensity was reached; that, once disturbed, it would fall in the direction opposite to that of the first disturbing thrust; and that no further shocks could affect the fallen indicator.

(6) *Negative evidence*

By negative evidence is meant those data which show that the vibrations of an earthquake could not have been very great without disturbing a condition found unaltered after the shock. One of the best types of negative evidence is that furnished by the rather numerous isolated chimneys left standing after the houses connected with them had burned. These have been noted near Beaupré on the north shore between Baie Saint Paul and Quebec, at many points on the island of Orleans, at Montmagny on the south shore (*see* fig. 22), and near Kamouraska. Many of these chimneys appear to be so insecure that it is remarkable that heavy winds have not thrown them over. That they withstood the earthquake tremors is conclusive proof that, at the points they occupy, the tremors were considerably less than at such places as Malbaie and Rivière Ouelle.

Near Chambord Junction on lake Saint John there was an old barn frame badly disintegrated and with all wall boards removed (*see* fig. 23). One upright leaned forward.

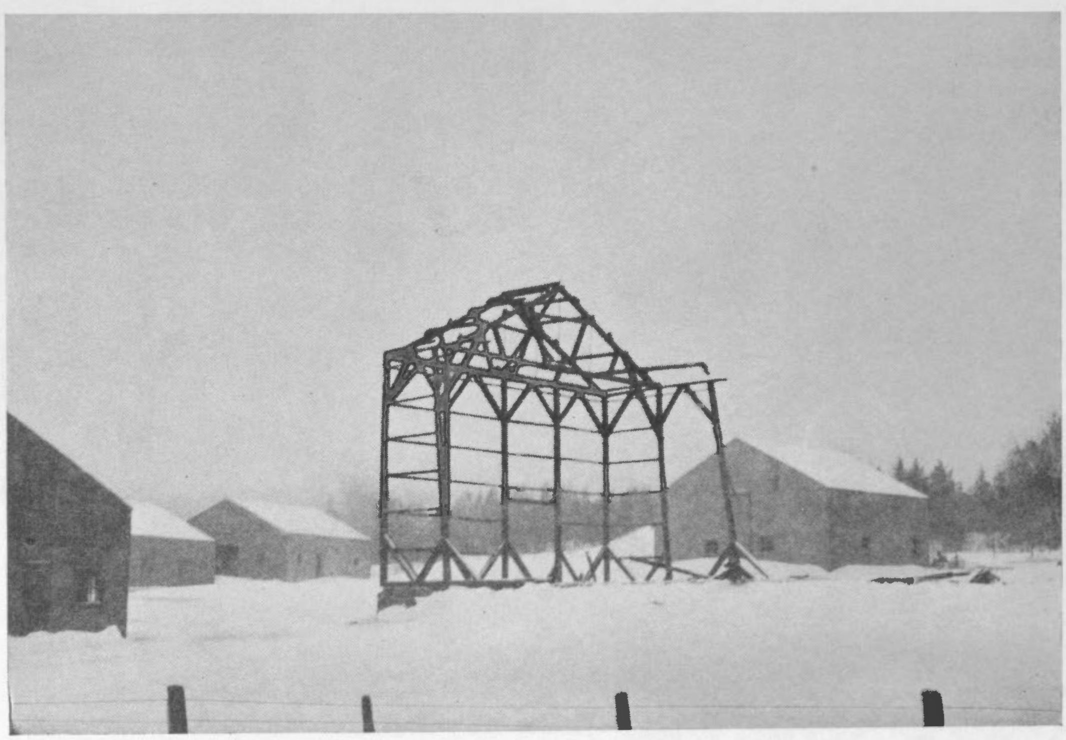

Fig. 23.—Old barn frame near Chicoutimi

It had a heavy beam tied to it on top and was free to fall except for the nails and braces at the base. The fact that it did not fall indicates that the fault must be nearer the Saint Lawrence river than to Chambord. This frees the fault running along the west side of the Saguenay up past lake Saint John from the suspicion of participation in the adjustment. The freedom from damage continues as far as Saint Félicien.

There was practically no damage in Chicoutimi. A street of houses built on sandy soil on the bank of the Saguenay was uninjured; not a chimney was damaged and no goods fell in the stores.

At the mill of the Port Alfred Pulp and Paper Co. on Ha! Ha! Bay a heavy "condenser" made of iron pipes filled with water was supported on reinforced concrete pillars. The entire equipment was thus in the form of an inverted pendulum. Some cracks were found in the tops of the pillars but examination showed them to be old cracks. They had not been further affected by the earthquake. It is not conceivable that the epicentre lay close to this place in the light of this and other negative evidence.

The above observations for Chambord Junction, Chicoutimi and Ha! Ha! Bay are grouped as negative evidence which precludes the location given by Prof. H. H. Turner in his publication "The International Seismological Summary for 1925, January, February, March" (Oxford, 1928), on page 56, as $\phi = 48° .2N$. $\lambda = 70° .8W$. This is within fifteen miles of Ha! Ha! bay and the condenser of the Port Alfred Pulp and Paper Co. and is within less than 25 miles of Chicoutimi. On page 57 of the same publication, the position of the epicentre is given as "in the mouth of the Saguenay river". The latitude and longitude given in figures by Prof. Turner place the epicentre nearer the source than the mouth of the river.

Great icicles were common in Quebec city at the time of the earthquake (*see* fig. 10). They were not displaced by it, when the houses on which they hung were on the rocky foundation in upper town. The ice statues and arches (*see* fig. 11) placed at various parts of the city were not disturbed by the earthquake, though in many cases they were top-heavy or rested on their bases at points of contact which might have been expected to shear off with any very sharp shock.

When investigating the epicentral region after the earthquake, the writer was told nearly every morning of after-shocks experienced during the night by other members of the household where he happened to be staying. He felt only one or two of these shocks himself. Most of them, even some which registered on seismographs or which were reported from other places by telegraph thus confirming the observer noting them, were quite unnoticed by him. Accordingly, after the first experience of this kind, it was his invariable custom, on retiring, to balance his fountain pen, vertically on its small end, on a smooth level surface. This made a top-heavy column which was somewhat difficult to place. Nevertheless, it was not overset by any of the reported after-shocks, experienced from March 7 to March 20, inclusive. This negative evidence, some of it obtained in locations where the soil is deep and where the vibrations might have been expected to exercise their greatest influence, indicates the feeble nature of most of the after-shocks. Those of March 6 and March 21 would undoubtedly have overset the pen.

III. LOCATION OF EPICENTRE BY QUESTIONNAIRES AND NEWS ITEMS

(1) *Sources and extent of information in Canada and in the United States*

At the time of the earthquake, questionnaires were distributed by the United States Coast and Geodetic Survey and requests for information were broadcast through the newspapers. Replies received were evaluated for intensity on the Rossi-Forel Scale (*See* Appendix A—page 427) and incorporated in an isoseismal map. Items were received from points as far south as Virginia and as far west as Minnesota. These items took the form of returned questionnaires, press clippings, and letters. The distribution of the returned items with respect to states is set forth in the following table:

SOURCES AND NATURE OF DATA COLLECTED IN THE UNITED STATES

States	Questionnaires	Clippings	Letters
Colorado	....	1	....
Connecticut	6	2	1
District of Columbia	....	5	1
Illinois	5	3	4
Indiana	13	8	....
Iowa	7	1	....
Kansas	1	....	....
Kentucky	2	....	....
Maine	7	1	1
Maryland	2	1	1
Massachusetts	20	1	2
Michigan	36	14	6
Minnesota	1	....	....
Missouri	....	....	1
New Hampshire	2	3	1
New Jersey	29	2	1
New York	16	57	16
North Carolina	1	....	....
Ohio	11	4	2
Pennsylvania	6	2	9
Rhode Island	5	1	....
Vermont	4	2	....
Virginia	4	....	....
West Virginia	2	....	....
Wisconsin	14	5	1
Totals	194	113	47

Questionnaires to the number of 222 were sent to well-distributed points in Canada to be filled in by postmasters and others. Special requests numbering 226 were addressed to the editors of newspapers in eastern Canada asking for clippings. Telegrams and special questionnaires were sent to persons from whom particular information was desired.

The data received were from places distributed as follows:

SOURCES AND NATURE OF DATA COLLECTED IN CANADA

Provinces	Questionnaires	News Clippings	Total
New Brunswick	8	7	15
Nova Scotia	11	7	18
Cape Breton	1	....	1
Prince Edward Island	2	1	3
Quebec	70	175	245
Ontario	56	140	196
Totals	148	330	478

In the case of the news clippings in the table immediately above, only the net number of those which gave values of intensity at different places is indicated. There were at least twice as many clippings which had to be checked over but which yielded only the 330 net values which could be used in preparing the isoseismal map.

(2) *Comments on the value of such data*

The work on this earthquake has convinced the writer that much of the material collected by questionnaires is of very little value as used for the preparation of isoseismal maps. The same is true of newspaper clippings. *Their real value lies in their being collected very promptly after an earthquake and forwarded at once to the investigator in the field.* To him, they are of considerable value as suggesting points of contact and lines of investigation.

In the first place, the data given are of little value for the determination of "intensity" because they are sent in by persons who are not known to those working on the earthquake. Many are sent in by quite incompetent observers. It is difficult, or impossible, to distinguish between good observers and poor ones, simply from a returned questionnaire.

In the second place, the evaluation of intensity by the Rossi-Forel scale, or any other scale that can be devised for application in a similar manner, is so poor as to be almost worse than valueless—it tends to be misleading. The application of all such scales depends on translating the sensations of the observer and the account of damage into the proper number of a "scale of intensity". The estimates of intensity based on the sensations experienced by observers are in most cases notoriously weak. Again, the damage caused by an earthquake is influenced by many factors: distance from the epicentre (perhaps also, the direction from the epicentre); nature of the terrain; the type of construction or the quality of its material and workmanship. Furthermore, it is not known whether it is the acceleration, the amplitude, the period, or some combination of these, which causes the destruction of buildings. Altogether, it seems hopeless to deduce anything very much worth while from questionnaires and press clippings *except as they are used as the basis of further investigation in the field.*

A great deal of time has been spent on the replies to questionnaires and on newspaper clippings, as will appear in the next subsection. In common with many other workers in seismology, the writer is hopeful that an efficient, economically-feasible scheme may soon evolve from present-day efforts to determine quantitatively the earthquake intensity over areas known to be liable to such disturbances.

(3) *Methods of preparation for analysis*

The questionnaires were sorted into groups, by provinces, within which they were arranged in alphabetical order by names of places. The information given by each questionnaire was typed on an analysis form, the French replies being translated into English. The forms so completed and arranged were given serial numbers for purposes of ready identification and reference. The various entries were then examined for evaluation on the basis of the Rossi-Forel scale, the number assigned being written in below the serial number of the analysis form.

A map was then prepared to include the northern section of the United States from Minnesota to the Atlantic and the provinces of Canada east of Manitoba. Over this map were laid two sheets of tracing linen, held at one common edge by drawing pins, so that registration might be conveniently and accurately maintained. The serial numbers of the analysis sheets were then plotted in the positions determined by the places respectively represented, all the serial numbers being plotted on the first sheet of tracing linen. As each serial number was plotted, the second tracing sheet was brought down over and the number indicating the evaluation on the Rossi-Forel scale was inserted on the second sheet immediately over the corresponding serial number beneath. It was thus possible at any time to determine the source of any scaled value at any point on the map.

The press-clippings, properly prepared for mounting, were sorted into alphabetical order on the basis of the place of publication. They were then mounted in a large scrap book. The items, one after another, were examined and those which gave information permitting the determination of intensity at any point (whether the place of publication or elsewhere) were given serial numbers continuous with and following those assigned to the questionnaires as transcribed on analysis forms. Some care was taken to avoid repetition of valuation numbers for any place. Where several reports applied to one place, the one requiring the highest scale number was the one selected for the purposes of the isoseismal map. The serial numbers were then plotted on the same tracing sheet with those of the analysis forms, the intensity numbers being plotted as before.

The second tracing sheet, with the scale values for both questionnaires and clippings plotted on it, was then laid over the map in proper registration and the isoseismals sketched in so that the locus of well-defined positions for any scale value at the points farthest from the epicentre were connected by a common isoseismal line. Where necessary, as at Quebec and at the Saint Maurice river, isoseismals were inserted which do not circle the epicentre. It was found that the isoseismals, as drawn for United States territory by the United States Coast and Geodetic Survey, fitted well with those indicated by our own data for Canada.

IV. LOCATION OF EPICENTRE BY MEANS OF SEISMOGRAMS

(1) *Sources of data*

The following table shows the seismograms which have been received and studied in connection with this earthquake:

Station	Instruments	Registration	Original or Copy	Components
Berkeley	Wiechert	Smoked Sheet	Original	NS
Berkeley	Wiechert	Smoked Sheet	Original	EW
Berkeley	Wiechert	Smoked Sheet	Original	Vertical
Bidston	Milne-Shaw	Photographic	Copy	NS
Cheltenham	Bosch-Omori	Smoked Sheet	Copy	NS
Cheltenham	Bosch-Omori	Smoked Sheet	Copy	EW
Chicago	Milne-Shaw	Photographic	Photostat	NS
Chicago	Milne-Shaw	Photographic	Copy	EW
Cleveland	Wiechert	Smoked Sheet	Original	NS + EW
Cleveland	Wiechert	Smoked Sheet	Original	Vertical
Fordham	Milne-Shaw	Photographic	Copy	NS
Fordham	Milne-Shaw	Photographic	Copy	EW
Georgetown	Wiechert	Smoked Sheet	Copy	NS + EW
Halifax	Mainka	Smoked Sheet	Copy	EW
Harvard	Bosch-Omori	Smoked Sheet	Copy	NS
Harvard	Bosch-Omori	Smoked Sheet	Copy	EW
Honolulu	Milne-Shaw	Photographic	Photostat	EW
Ottawa	Milne-Shaw	Photographic	Original	NS
Ottawa	Milne-Shaw	Photographic	Original	EW
Ottawa	Bosch	Photographic	Original	NS + EW
Ottawa	Wiechert	Smoked Sheet	Original	Vertical
Saskatoon	Mainka	Smoked Sheet	Original	NS
Saskatoon	Mainka	Smoked Sheet	Original	EW
Sitka	Bosch-Omori	Smoked Sheet	Copy	NS
Sitka	Bosch-Omori	Smoked Sheet	Copy	EW
Stonyhurst	Milne-Shaw	Photographic	Copy	EW
Toronto	Milne-Shaw	Photographic	Copy	NS
Toronto	Milne-Shaw	Photographic	Original	EW
Tucson	Bosch-Omori	Smoked Sheet	Copy	EW
Uccle	Galitzin	Photographic	Copy	NS
Uccle	Galitzin	Photographic	Copy	EW
Victoria	Milne-Shaw	Photographic	Copy	NS
Victoria	Milne-Shaw	Photographic	Copy	EW

The above tabulation shows component records from a total of 18 stations. Besides these records and copies of records, bulletins of readings for this earthquake were received from the following stations:

Agram, Alicante, Algiers, Almeria, Baku, Barcelona, Belgrade, Cartuja, Coimbra, Denver, Ekaterinburg, Eskdalemuir, Firenze, Hamburg, Helwan, Innsbruck, Ithaca, Königsberg, Kucino, La Paz, La Plata, Lemberg, Lick, Malaga, Manila, Melbourne, New Orleans, Osaka, Paris, Perth, Piatigorsk, Pulkovo, Rio de Janeiro, Saint Louis, San Fernando, Spring Hill, Strasbourg, Toledo, Wien, Zi-ka-wei, and Zürich.

Some of the above records were incomplete for various reasons and so yielded no determination for distance to the epicentre. Of the 59 stations from which some data were received, 39 are in satisfactory agreement with the epicentre adopted, the distance circles for 20 of them passing through that position and the others within 25 miles or less. Copies of the Milne-Shaw horizontal records for Ottawa and that of the Wiechert vertical for the same station are shown in fig. 24.

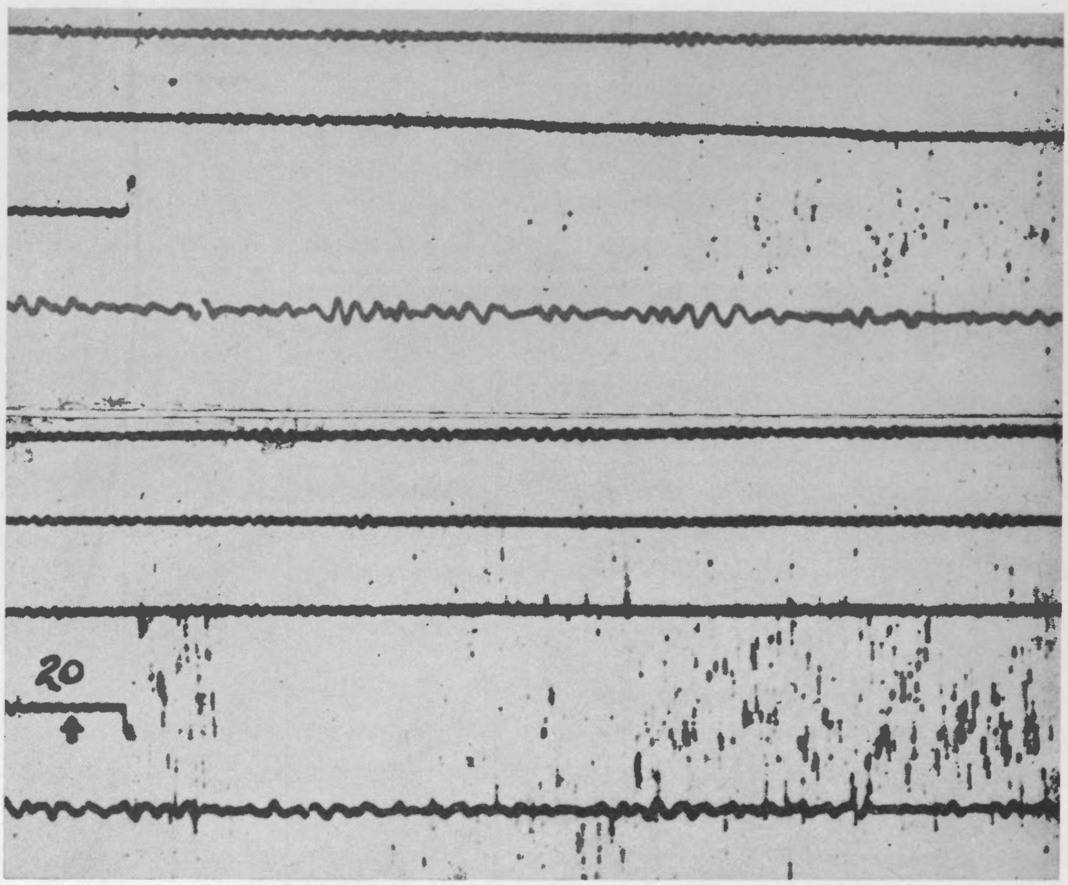

FIG. 24.—Initial sections of the Ottawa seismograms of the Saint Lawrence Earthquake of 1925

1. Milne-Shaw, north-south component.
2. Milne-Shaw, east-west component.

(Note the almost equal initial displacements on both components, indicating an epicentre in an azimuth due north-east or south-west. The first displacement on the vertical, which is too faint for reproduction, gave the information as to the required distinction, placing the epicentre as north-east from Ottawa. The east-west record was sufficiently legible to give distance, placing the epicentre as on or near the Saint Lawrence and about forty miles, more or less, below Quebec city—information given to the press the night of the earthquake.)

(2) *Presentation of summarized data*

In the following table are presented the values for epicentral distances (Δ), and time at origin in Greenwich Mean Time (0), together with the times of arrival of the direct longitudinal waves (P) and the direct transverse waves (S), for each of the 30 stations used in the determination of the epicentre. The determination of 0 and Δ from P and S is, in each case, based on the Klotz tables (Publications of the Dominion Observatory, Vol. 3, No. 2, Ottawa, 1916). The stereographic projection method indicated in that publication, which permits the projection of the distance circles, still as circles, on the plane of the equator, has been used to find the point of intersection of the distance circles. The work of reading the various records and the draughting of the stereographic projection chart by means of which the location was effected have been done by Mr. W. W. Doxsee, of this Division, whose co-operation in this and also in other parts of the work has been of material assistance.

DATA USED IN THE LOCATION OF THE EPICENTRE

Stations	P	S	O	Δ
	h m s	h m s	h m s	km
Agram	2-29-00	2-36-46	2-19-19	6180
Alicante	2-28-08	2-35-28	2-18-55	5700
Almeria	2-28-07	2-35-14	2-19-10	5450
Berkeley	2-26-42	2-32-43	2-19-06	4250
Cartuja	2-28-06	2-35-12	2-19-10	5440
Cleveland	2-21-45	2-23-35	2-19-31	1020
Coimbra	2-27-24	2-33-56	2-19-08	4820
Ekaterinburg	2-30-18	2-39-18	2-19-18	7610
Fordham	2-21-02	2-22-20	2-19-27	710
Georgetown	2-21-46	2-23-38	2-19-29	1040
Halifax	2-20-48	2-21-53	2-19-28	590
Helwan	2-31-02	2-40-43	2-19-19	8420
Königsberg	2-28-39	2-36-14	2-19-09	5990
La Paz	2-29-49	2-38-18	2-19-21	7000
La Plata	2-31·8	2-42·0	2-19·6	9020
Malaga	2-27-59	2-35-03	2-19-05	5400
Ottawa	2-20-26	2-21-19	2-19-20	480
Piatigorsk	2-30-46	2-40-06	2-19-25	8000
Pulkovo	2-28-48	2-36-30	2-19-11	6110
Rio de Janeiro	2-30-56	2-40-30	2-19-20	8280
Saint Louis	2-23-15	2-26-15	2-19-32	1750
Saskatoon	2-24-31	2-28-45	2-19-12	2610
Spring Hill	2-24-22	2-28-20	2-19-24	2410
Stonyhurst	2-27-06	2-33-26	2-19-05	4600
Strasbourg	2-28-11	2-35-20	2-19-11	5500
Toledo	2-27-47	2-34-33	2-19-14	5070
Toronto	2-21-07	2-22-30	2-19-25	760
Victoria	2-26-08	2-31-48	2-19-00	3870
Wien	2-28-45	2-36-24	2-19-11	6050

V. CONCLUSIONS WITH REGARD TO THE EPICENTRE

The position of the epicentre which agrees best with the above instrumental data, and which is also in accord with the work in the field, is determined as being

$$\phi = 47°.6\text{N}.$$
$$\lambda = 70°.1\text{W}.$$

These co-ordinates define a point in the Saint Lawrence river between the mouth of Malbaie river on the north and that of Rivière Ouelle on the south. It is to be understood that the epicentre is not to be considered a point, but rather a zone, the major axis of which lies NNW–SSE and which has a mid-point as indicated. It is quite possible that the line of adjustment projected somewhat into the north shore, though there are no observational data which definitely establish such a projection. It is probable that the line of adjustment entered the south shore as far as the rising land to the south of Sainte Anne de la Pocatière and Saint Pacôme, passing between these two villages. There is some evidence to support this projection.

It is believed that the territory immediately to the north and east of the fault snapped upward and, possibly, that it also had a horizontal component of motion, moving somewhat to the southwest. The territory to the south and west moved horizontally north and east. These conclusions are supported by the instrumental records and also by the investigations in the field. If the territory to the west and south of the hypothetical fault had a vertical component of motion at the time of the earthquake, it was downward.

VI. ADDITIONAL CONFIRMATORY DATA

(1) *Supporting Evidence of the After-shocks*

The after-shocks of the earthquake were carefully studied. A close observer, living near the epicentral region, tabulated 11 strong shocks during the day following the earthquake. During the waking hours of the first week he recorded a total of 37 well-marked shocks. During the night of February 28–March 1 (*Eastern Standard Time will be used in every case throughout this section dealing with reports of after-shocks*) the shocks were "almost continuous"; certainly very frequent (four besides the main shock being recorded at Ottawa).

As an indication of the frequency of the earthquakes during the night of February 28–March 1, it may be repeated that the occupants of the jail at Malbaie, as well as others in that village, assert that the tremors continued at intervals of a few minutes all night. The questionnaires returned from Saint Hilarion state that 25 tremors were recorded that night. At Saint Jean Port Joli, 8 shocks were reported.

Special mention may be made of the after-shock of 9:30 p.m., Friday, March 6. The shock, observed by the writer at Pointe au Pic, was quite marked, lasting for from five to ten seconds and causing one to wonder if the house would really stand the strain.

A much more severe shock occurred on March 21, at about 10:20 a.m. It was felt over a wide area and caused alarm as far away as Quebec city.

A special study was made of several relatively weak shocks. The first of these was one experienced on April 10 at 4:30 a.m. when the writer was at Saint Pascal. Telegrams were at once sent to Malbaie and to Chicoutimi, asking whether a shock had been felt but not giving the hour. Replies were received which checked with the report of observers at Saint Pascal (the writer did not notice the tremors himself), and showed that the earthquake was felt at Malbaie and at Chicoutimi but that it was not felt at Saint Bruno, only about 6 miles south of Saint Pascal.

The second earthquake occurred on April 25 at 11:50 p.m. It was also investigated by telegram and questionnaires, to the effect that it was felt at Chicoutimi and at Sainte Anne de la Pocatière but was not felt at any of the stations on the Canadian National transcontinental railway line, which parallels the shore of the Saint Lawrence river, about 20 miles south of the line through Saint Pascal. The stations from Monk to Rivière Bleue all reported the tremor as not felt.

Similar telegraphic investigation was carried out for a quake felt at Saint Pascal and Kamouraska at 6:30 a.m., April 11, but not felt at Saint Bruno.

The general testimony of all the telegraphic investigations was that the after-shocks originated in the general vicinity of Malbaie, Kamouraska, Saint Pascal, and Rivière Ouelle. Some of the stronger ones were felt at Sainte Anne de la Pocatière. Moderately strong shocks were noted as far north as Chicoutimi though quite unnoticed at Saint Bruno and points on the Canadian National transcontinental line. If the tremors were very weak the observations at Kamouraska, Saint Pascal, and Malbaie checked, but other places reported the tremors as not felt. The evidence of the after-shocks thus checks the deductions of section V.

The complete list of after-shocks, in order of occurrence, is tabulated as follows:

AFTER-SHOCKS NOTED UP TO JULY 31, 1925

Date		Time	Remarks
Feb.	28	11-30-42 p.m.	Felt generally, Malbaie, Tadoussac, Chicoutimi, Baie Saint Paul, Quebec, Lèvis to Trois Pistoles on South Shore. Recorded at Ottawa.
Mar.	1	1-25-21 a.m.	Felt generally over same area as above. Recorded at Ottawa.
"	1	2-25-10 a.m.	A strong shock; felt generally as above. Recorded at Ottawa.
"	1	8-21·5 a.m.	Felt generally over epicentral area; and recorded at Ottawa.
"	1	9-10 a.m.	Recorded by observer at Pointe au Pic. An asterisk indicates the other shocks reported by the same observer. (Daytime observing only)
"	1	9-20 a.m.	*
"	1	9-30 a.m.	*
"	1	10-39 a.m.	*
"	1	11-27 a.m.	*
"	1	12-24 p.m.	*
"	1	1-35 p.m.	*
"	1	2-55 p.m.	*
"	1	3-26 p.m.	*
"	1	4-15 p.m.	*
"	1	7-15 p.m.	*
"	2	6-35 a.m.	*
"	2	9-42 a.m.	*
"	2	9-43 a.m.	*
"	2	10-49 a.m.	*
"	2	3-25 p.m.	*
"	2	3-25 p.m.	*
"	2	5-26 p.m.	*
"	2	6-14 p.m.	*
"	2	6-45 p.m.	*

AFTER-SHOCKS NOTED UP TO JULY 31, 1925—*Concluded*

Date		Time		Remarks
Mar.	3	6-05	a.m.	Reported by observer at Pointe au Pic. An asterisk indicates the other shocks reported by the same observer. (Daytime observing only)
"	3	8-23	a.m.	*
"	3	11-15	a.m.	*
"	3	2-34	p.m.	*
"	3	6-33	p.m.	*
"	3	10-25	p.m.	*
"	4	2-30	p.m.	*
"	5	12-20	p.m.	*
"	5	3-32	p.m.	*
"	5	5-45	p.m.	*
"	5	6-43	p.m.	*
"	6	7-34	a.m.	*
"	6	10-30	a.m.	*
"	6	2-10	p.m.	*
"	6	9-30	p.m.	* This earthquake was also felt by the writer while at Point au Pic as has been mentioned on page 416. Reports show that it was felt at Trois Pistoles, Rivière du Loup, Saint Pacôme, Rivière Ouelle, Tadoussac, Chicoutimi, and Malbaie. It was recorded at Ottawa.
"	6	11-30	p.m.	*
"	7	7-00	p.m.	* Also felt by the writer while at Pointe au Pic.
"	8	9-02	a.m.	* Also felt by the writer while at Pointe au Pic.
"	8	10-42	a.m.	*
"	8	5-45	p.m.	* Also felt by the writer while at Pointe au Pic.
"	11	?	?	Reported from Malbaie as two shocks.
"	14	10-18	a.m.	Reported from Chicoutimi and from a point in the woods about midway between Chicoutimi and Malbaie. Registered at Ottawa.
"	17	9-45-20	a.m.	Registered at Ottawa. Presumably felt in epicentral region.
"	18	8-15-22	a.m.	Registered at Ottawa. Presumably felt in epicentral region.
"	21	10-22-24	a.m.	Reported as felt at Misère, Saint Adalbert, Saint Donat, Rivière du Loup, Malbaie, Ha! Ha! Bay. Registered at Ottawa. A very sharp earthquake which was felt as far west as Quebec city.
Apr.	10	4-30	a.m.	Felt at Saint Pascal, Malbaie, and Chicoutimi. Not felt at Saint Bruno.
"	11	6-30	a.m.	Felt at Saint Pascal, Malbaie, and Chicoutimi. Not felt at Saint Bruno.
"	25	11-50	p.m.	Felt at Paint Pascal, Kamouraska, Sainte Anne de la Pocatière, and Chicoutimi. Not felt on Canadian National railway from Monk to Rivière Bleue.
July	26	9-20	p.m.	Felt at Sainte Anne de la Pocatière but not investigated further.
"	27	4-00	a.m.	Felt at Sainte Anne de la Pocatière but not investigated further.

The writer wishes to acknowledge the assistance of a number of careful observers in connection with the investigation of the after-shocks. In particular, the following were able to render valuable coöperation in this work:

M. J. Beaulieu, Telegraph operator at Monk, Que.

M. Antoine Dubuc, Manager of the telephone company at Chicoutimi.

M. J. B. Dupuis, Manager of the telephone company at Rivière du Loup.

M. E. Guillemette, Telegraph operator at Pointe au Pic.

M. Joseph Lavoie, Telegraph operator at Saint Pascal.

M. F. Vincent, Telegraph operator at Malbaie.

To sum up, a study of the after-shocks indicates that they were always felt in the region near the assigned epicentre. If rather weak, they were felt on the south shore of the

Saint Lawrence, only within a belt 5 to 6 miles wide adjacent to the river. Such weak shocks were felt on the north shore, however, sometimes as far as Chicoutimi, a fact which lends weight to the statement that the epicentre may be an elongated one, lying along a fault extending into the north shore of the Saint Lawrence.

(2) *Supporting Evidence of Level Lines Re-run*

Immediately after the earthquake, steps were taken to find any controls which might yield quantitative measurements as to permanent displacements. The only level line run in the area was that from Lévis to Rivière du Loup. This had been completed in 1915. A request to the Director of the Geodetic Survey resulted in arrangements being made by which that organization re-ran the line of levels between these two towns. The result of that work may be said to have revealed no differences greater than the order of the errors of observation. However, the differences east of Saint Pacôme and Rivière Ouelle, were all in the same sense, the 1925 elevations being above those of 1915: all the differences west of that point were in the opposite sense, the 1925 elevations being below those for 1915, when the Lévis end of the line is considered fixed in elevation.

The observations, together with the descriptions of bench-marks, have been furnished by the Director of the Geodetic Survey.

TABLE SHOWING COMPARATIVE ELEVATIONS OF PRECISE LEVEL BENCH MARKS ALONG CANADIAN NATIONAL RAILWAY FROM RIVIÈRE DU LOUP TO LÉVIS, QUE.

B.M. No.	Location	Elev. 1915	Elev. 1925	Diff.
821-B	C.N.R. bridge at Rivière du Loup	303·30	303·30	·00
580-B	Concrete monument 2 miles west of Rivière du Loup	329·67	329·67	·00
MCLXIV	Stone culvert 2¼ miles west of Rivière du Loup	321·89	321·84	− ·05
579-B-2	Tile culvert 1 mile east of Old Lake Road	350·61	350·58	− ·03
MCLXVI	Large stone culvert 350 feet west of Old Lake Road	336·50	336·48	− ·02
MCLII	Tile culvert 2 miles east of Saint Alexandre	414·48	414·48	·00
MCLI	Saint Alexandre station house	369·47	369·46	− ·01
579-B	Stone box culvert 1½ miles east of Saint André	345·26	345·19	− ·07
MCXLIX	Stone culvert ½ mile west of Saint André	338·18	338·11	− ·07
MCXLVIII	Tile culvert ¾ mile west of Saint Hélène	311·48	311·48	·00
577-B	Bridge ½ mile east of Dessaint	308·74	308·78	+ ·04
MCXLV	Bridge ½ mile east of Saint Pascal	219·39	219·41	+ ·02
MCXLVI	Saint Pascal Roman Catholic Church	183·84	183·83	− .01
MCXLIV	Tile culvert ¼ mile west of Saint Pascal	184·77	184·73	− ·04
576-B	Bridge 1¼ miles west of Saint Pascal	173·48	173·42	− ·06
MCXLIII	Bridge 3 miles east of Saint Philippe de Néri	191·74	191·69	− ·05
575-B	Tile culvert 1½ miles east of Saint Philippe de Néri	178·19	178·17	− ·02
27-G	Tile culvert at Saint Philippe de Néri	145·02	145·02	·00
MCXLII	Tile culvert ¼ mile west of Saint Philippe de Néri	135·94	135·90	− ·04
MCXXXIX	Tile culvert 2¼ miles east of Rivière Ouelle	97·90	97·89	− ·01
MCXXXVIII	Tile culvert 1 mile east of Rivière Ouelle	62·55	62·54	− ·01
MCXXXVII	Rivière Ouelle station house	48·38	48·30	− ·08
MXCV	Bridge ½ mile west of Rivière Ouelle	35·16	35·08	− ·08
MXCVI	Rock mass at Saint Pacôme	53·77	53·73	− ·04
MXCVIII	Large culvert 1¾ miles east of Sainte Anne de la Pocatière	70·39	70·25	− ·14
MIC	Bridge ½ mile west of Sainte Anne de la Pocatière	96·16	95·97	− ·19
573-B	Tile culvert 2¾ miles west of Sainte Anne de la Pocatière	93·96	93·78	− ·18
572-B	Boulder 3 miles east of Sainte Louise	101·46	101·25	− ·21
MCIV	Bridge 1¼ miles west of Sainte Louise	129·75	129·61	− ·14

TABLE SHOWING COMPARATIVE ELEVATIONS OF PRECISE LEVEL BENCH MARKS ALONG CANADIAN NATIONAL RAILWAY FROM RIVIÈRE DU LOUP TO LÉVIS, QUE.—*Concluded*

B.M. No.	Location	Elev. 1915	Elev. 1925	Diff.
MCV	Stone culvert 1 mile east of Elgin Road	146·83	146·69	− ·14
571-B	Tile culvert ¾ mile west of Elgin Road	165·73	165·59	− ·14
MCVI	Tile culvert ¾ mile west of Saint Jean Port Joli	162·11	161·93	− ·18
570-B	Bridge 1¼ miles west of Saint Jean Port Joli	153·27	153·09	− ·18
MCVIII	Rock exposure 1¾ miles east of Trois Saumons	136·07	135·87	− ·20
MCIX	Boulder at Trois Saumons	99·45	99·24	− ·21
MCXXIII	Culvert ¾ mile west of Trois Saumons	70·25	79·03	− ·22
MCXXII	Tile culvert 1½ miles east of L'Islet	71·75	71·51	− ·24
569-B	Bridge 1 mile east of L'Islet	77·13	76·86	− ·27
568-B	L'Îslet station house	104·84	104·65	− ·19
MCXX	Tile culvert ¾ mile west of L'Islet	104·35	104·12	− ·23
567-B	Large boulder ½ mile east of Cap Saint Ignace	122·62	122·29	− ·33
MCXVIII	Stone culvert 1½ miles west of Cap Saint Ignace	105·92	105·59	− ·33
MCXVII	Boulder 3¼ miles east of Montmagny	72·70	72·38	− ·32
MCXVI	Boulder 2¼ miles east of Montmagny	54·23	53·86	− ·37
MCXV	Boulder 1¾ miles east of Montmagny	53·78	53·43	− ·35
566-B	Bridge ½ mile east of Montmagny	53·70	53·13	− ·37
MCXIII	Stone culvert 1¾ miles west of Montmagny	90·97	90·64	− ·33
564-B	Concrete monument 1¼ miles west of Saint Pierre	135·89	135·65	− ·24
MCXI	Stone culvert 1¼ miles east of Saint François	127·71	127·46	− ·25
MCX	Stone culvert ½ mile west of Saint François	128·82	128·55	− ·27
MCXXIV	Tile culvert 1½ miles east of Saint Vallier	151·12	150·89	− ·23
MCXXV	Open culvert at Saint Vallier	146·52	146·28	− ·24
MCXXVI	Stone culvert 1 mile east of La Durantaye	164·31	164·09	− ·22
563-B	Tile culvert at La Durantaye	169·44	169·22	− ·22
MCXXVIII	Small culvert 1 mile west of La Durantaye	178·00	177·79	− ·21
MCXXIX	Bridge 3¾ miles east of Saint Charles Junction	167·48	167·25	− ·23
MCXXX	Small culvert 2½ miles east of Saint Charles Junction	205·19	205·00	− ·19
MCXXXI	Stone culvert ½ mile east of Saint Charles Junction	283·20	283·04	− ·16
MCXXXII	Stone culvert 1½ miles west of Saint Charles Junction	322·70	322·51	− ·19
MCXXXIII	Stone culvert 4 miles west of Saint Charles Junction	306·64	306·47	− ·17
MCXXXV	Stone culvert at Harlaka	239·62	239·46	− ·16
219-B	Subway 1 mile west of Harlaka	177·10	176·94	− ·16
CLXVI	Same subway as above	167·69	167·52	− ·17
MCXXXVI	Subway (main road) at Lauzon	72·83	72·68	− ·15
220-B	Subway, road to Lauzon dry dock	66·84	66·69	− ·15
LXXIII	Same subway as above	58·14	57·99	− ·15
LXXIV	Lauzon dry dock	15·97	15·84	− ·13
221-B	Lévis Post Office	19·34	19·21	− ·13

NOTE.—Attention is drawn to the fact that the above holds the elevation at Rivière du Loup constant, while the graph holds the elevation at Lévis to be unchanged.

The results of the two sets of levelling, arranged with the Lévis end held constant, are shown graphically in fig. 25. It will be noted that the change in sense of the observed differences appears at a point between the station at Sainte Anne de la Pocatière and the station at Saint Pacôme. (It is to be remembered that the levels were run along the railway.)

Although the observed differences are small they are significant in that they arrange themselves as all in the same sense on one side of a given point and in the opposite sense

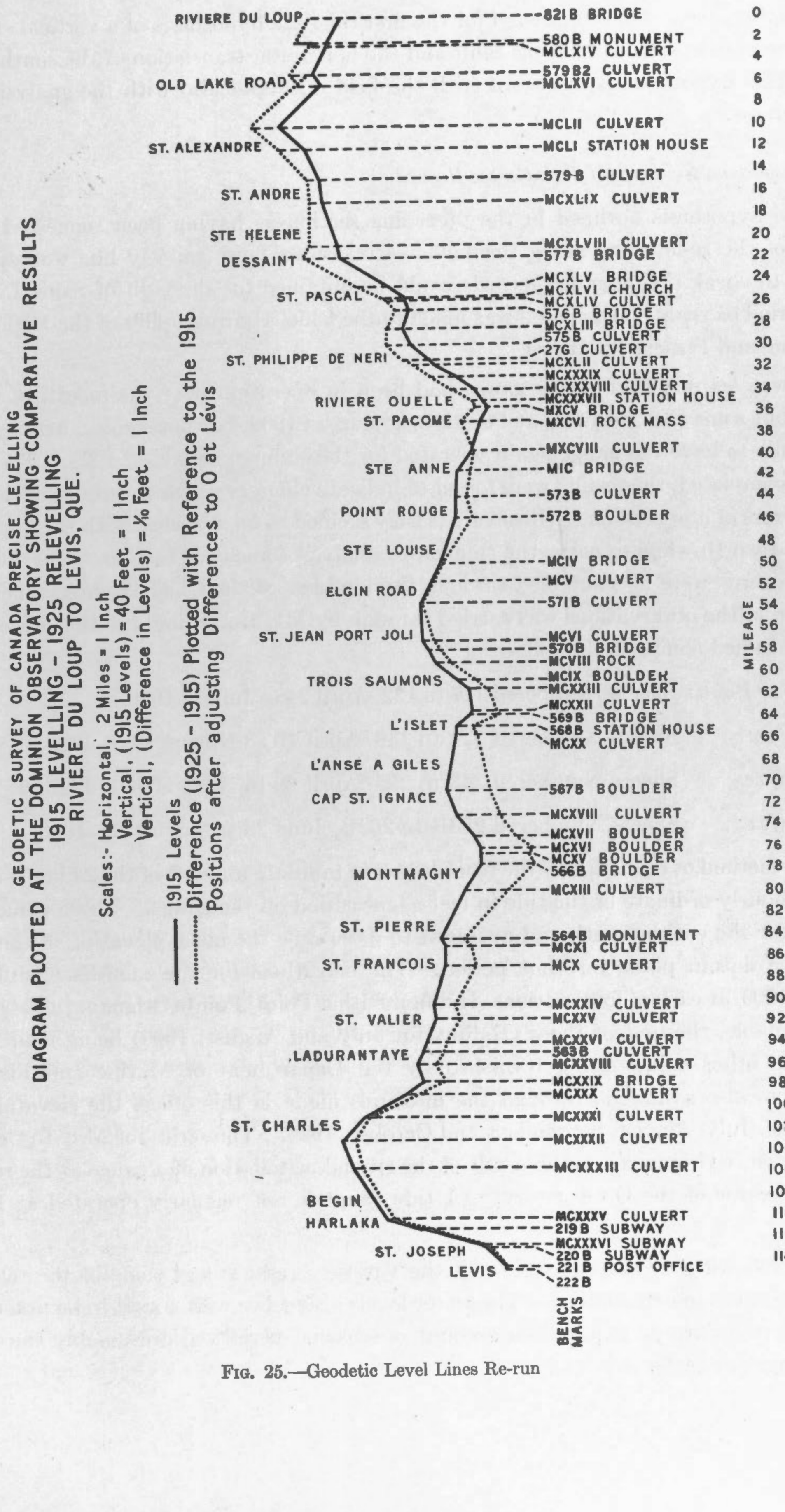

FIG. 25.—Geodetic Level Lines Re-run

on the other side. They suggested for the first time the hypothesis of a vertical snapping up of the northeastern side of the fault and the horizontal translation of the southwestern side. This hypothesis is in accord with the field data and also with the analysis of the seismograms.

(3) *Supporting Evidence of Tide Gauge Record*

The hypothesis outlined in the preceding section as having been suggested by the results of the re-levelling along the Lévis—Rivière du Loup railway line was evidently subject to check if tide gauge records could be obtained for the Gulf of Saint Lawrence for a period of years. An appeal was made to the Chief Hydrographer of the Department of Marine and Fisheries, Ottawa.

It was learned that a tide gauge had been in operation near the mouth of Rivière Ouelle, but somewhat below it, at Pointe Orignaux, in 1900, but not since. Arrangements were made to have the gauge again operated for the summer season of 1926. The observations completed, the results were found to indicate changes which were only of the order of the errors of observation. However, as they seemed to be in accord with the hypothesis it seemed worth while to carry the tide gauge analysis somewhat further. The following sets of records were also supplied through the kindness of the Chief Hydrographer. The reduction of the observations was carried through by Mr. J. Archibald in this office. The records studied comprise the following:

Father Point: Sheets Numbered 117 to 122, April 24 to June 5, 1926.

Quebec: Sheets Numbered 121 to 149, April 19 to November 1, 1926.

Halifax: Sheets Numbered 243 to 295, April 29 to November 1, 1926.

Halifax: Sheets Numbered 253B to 262B, June 28 to August 30, 1900.

The method of reduction of the records was to tabulate for each of the 24 hours of each day the hourly ordinate of the tide in feet as measured on the gauge. These values were totalled for the entire month and averaged to determine the mean elevation of the water above the datum plane for that period. The elevations for the months of July and August, 1900, at each of four stations (Halifax, Father Point, Pointe Orignaux, and Quebec) were available, the first of these (Halifax for July and August, 1900) being read in this office, the other values being furnished by the Department of Marine and Fisheries. There were also available, through the measures made in this office, the elevations for May, June, July, August, September, and October, 1926. The series for May to October, 1926, at Pointe Orignaux was the result of the special installation of a gauge at the request of the Director of the Observatory. (A tide gauge is not regularly operated at Pointe Orignaux.)

The following tabulation sets forth the various averages and some of the relations which they bear to one another. The water levels at Quebec were found to be practically useless for the purpose required on account of seasonal variation, presumably caused by meteorological effects.

WATER LEVELS FROM TIDE GAUGES

Dates	Halifax (H)	Father Point (F)	Orignaux Point (O)	Quebec (Q)	F-H	O-H	O-F
1900 July	3·19	7·35	9·80	8·97	4·16	6·61	2·45
Aug.	3·54	7·04	9·57	8·55	3·50	6·03	2·53
1926 May	3·57	7·47	9·13	9·37	3·90	5·56	1·66
June	3·44	7·65	9·20	8·55	4·21	5·76	1·55
July	3·46	7·45	9·04	8·20	3·99	5·58	1·59
Aug.	3·60	7·43	9·08	8·06	3·83	5·48	1·65
Sept.	3·55	7·29	9·03	7·96	3·74	5·48	1·74
Oct.	3·77	7·68	9·37	8·18	3·91	5·60	1·69
Variation May-Oct.	·33	·39	·34	1·41	·47	·28	·19
Average 1900	3·36	7·19	9·68	....	3·83	6·32	2·49
Average 1926	3·56	7·49	9·14	....	3·93	5·58	1·65
Difference	− ·20	− ·30	·54	....	− ·10	·74	·84
Average 1900	3·36	7·19	9·68	....	3·83	6·32	2·49
Average July-Aug. 1926	3·53	7·44	9·06	....	3·91	5·53	1·62
Difference	− ·17	− ·25	·62	....	− ·08	·79	·87

The results for Halifax, Father Point and Pointe Orignaux are quite consistent, and are valuable for the purpose of testing the above-mentioned hypothesis. The analysis in the last three columns of the table indicates that there has been no change of any importance in the relative levels of Father Point and Halifax between 1900 and 1926, while the evidence is very strong for an upheaval of about three-quarters of a foot at Pointe Orignaux during the same interval.

These results, then, entirely confirm the hypothesis as to the approximate location of the fault line of the earthquake, and the general displacement at that time.

Considerable interest was taken in this particular part of the analysis by the Director of the Observatory. The plan of bringing the monthly averages furnished by the reduction of the tide gauge records into the form of the above table which clearly shows their relationships and demonstrates the agreement of the water-level data with the hypothesis as to the position and nature of the epicentre was the result of his analysis of the reduced data.

(4) *Supporting Evidence of Tidal Loading*

At the time of the earthquake the high estuary tide had passed the mouth of Rivière Ouelle, loading the bed of the Saint Lawrence within the hypothetical fault line, as far as Quebec. It was three and a half hours past high tide at Father Point at the time of the shock, and was within an hour of high tide at Lévis at the same moment. Apparently the warping strain had nearly reached the breaking point, the swing of tidal load from the northeast side to the southwest side of the fault serving to set off the earthquake.

VII. PROBABLE CAUSE OF THE EARTHQUAKE

A statement as to the cause of any tectonic earthquake must, of course, be largely speculative. Nevertheless, the following explanation agrees with the field data and with the supporting evidence set forth in the sections immediately preceding.

Based on the evidence of the level lines re-run it may be assumed that the Atlantic coast is slowly rising, or at any rate that it has a tendency to rise, due, possibly, to re-adjustment following the relief of glacial ice loading, which may still be under way. As will be shown in Appendix B. there have been recurrences of relatively severe earthquakes in the Saint Lawrence valley in cycles of about 60 years. It is possible that the strain is adjusted thus at intervals.

To explain all the data, we may suppose a fault crossing the Saint Lawrence river passing into the north shore near Malbaie and entering the south shore between the mouth of Rivière Ouelle and Pointe Orignaux. The fault would be supposed to pass to the east of the church at Rivière Ouelle and to the west of the station at Saint Pacôme. The strike of the fault is N., 50° W. It may be considered as dipping toward the ENE.

The "trigger" causes which set off the earthquake may be two in number. A long period of dry weather in the east had possibly resulted in a lightening of the normal load on the Atlantic seaboard. Such a condition would tend to hasten the relief afforded by the earthquake. The estuary tide effect, discussed in the preceding section, was probably the final local change in surface load which set off the earthquake.

VIII. SUMMARIZED CONCLUSIONS

1. The earthquake occurred March 1, $2^h\ 19^m\ 20^s$, Greenwich Mean Time (February 28, $9^h\ 19^m\ 20^s$ p.m., Eastern Standard Time.)

2. The epicentre was $\varphi = 47°.6$ N. $\lambda = 70°.1$ W. but is to be considered as an elongated zone about a fault crossing the Saint Lawrence river from a point near Malbaie on the north shore to a point between the mouth of Rivière Ouelle and Pointe Orignaux on the south shore. The fault seems to lie west of Pointe Orignaux, east of the church at Rivière Ouelle and west of the station at Saint Pacôme. It probably extends up into the north shore above Malbaie but not for any considerable distance. The disturbed zone does not reach farther south than the rising land to the south of Saint Pacôme village.

3. The greatest damage occurred in three areas—in the immediate vicinity of the epicentre—at Quebec city close to the Saint Charles river—along the valley of the Saint Maurice. The damage at the last two of these was due largely to insecure foundation soil or to poor or improperly designed construction.

4. No deaths occurred which could be attributed directly to the earthquake. Four, or perhaps five, persons died as the result of shock, which was attributed to the earthquake.

5. No fires were caused by the earthquake in spite of the fact that it occurred in midwinter in a country where the houses were mostly frame and heated by stoves, many of which were overturned by the shock.

6. Frame houses seem admirably designed to withstand earthquakes such as may reasonably be expected to occur in this region, especially when the sheeting is applied diagonally, the studding being run through unbroken from sill to plate.

7. Chimneys should be housed in chutes or frames so that their collapse will not injure anyone in the house.

8. Pictures, crucifixes, etc. should be placed so that they will not fall on a bed, particularly where there are small children.

9. In case of an earthquake, the first thought of a householder in the epicentral region, living in a frame house, should be to take care that overturned stoves or lamps do not set fire to anything. It may be confidently expected that the shocks will not demolish the house if it is at all reasonably well-built.

10. Stone houses should not be built on deep alluvium in the Saint Lawrence lowlands. This type of structure is particularly liable to damage and is dangerous to those within.

11. Steel frame construction is admirably suited to structures designed for this region, provided it is so designed that its vibration will not batter down filler walls or adjacent construction of brick. When reinforced by concrete it would seem to be particularly earthquake resistant, but the effects at the grain elevators at Quebec city prove that even such earthquakes as we may experience in Eastern Canada can seriously damage or even destroy such buildings when they are located on deep fill. Unfortunately, such locations have been chosen in a number of cases for buildings of this type, housing heavy machinery, within striking distance of the epicentre of this last earthquake, an epicentre which, we may safety assume, will again be active sooner or later.

12. Top heavy structures, brick stacks, water tanks, etc., should be built, where possible, on secure rocky bases, but in any case they should be placed so that their swaying or collapse may not endanger life or property.

13. The investigations carried out with regard to this earthquake indicate that questionnaires as returned by volunteer observers or those to whom a general appeal has been made at the time of a heavy earthquake are almost valueless as the basis of an isoseismal map. Many examples were found where the replies sent exaggerated conditions. Some minimized them. Some reports were found on investigation to be absolutely lacking in foundation. These erroneous reports are often—generally in fact—forwarded in perfectly good faith. The value of questionnaires appears when they are secured promptly and forwarded directly to the investigator in the field to be used as suggestions of points of contact, or lines of investigation.

14. The time has come when the investigation of earthquakes in the field must be planned in advance of the shock. If the work is to be of any use to the engineer (and it is but a reasonable requirement that it should be) some sort of seismoscope must be devised which shall be so cheap that it can be produced for, say, ten or fifteen dollars, and which shall be capable of indicating the horizontal component of the direction of motion of the first movement of a given acceleration. If it can also record the maximum acceleration and maximum amplitude, so much the better.

These seismoscopes are to be set up in secure positions at many points of vantage in the area to be studied, the basements of schools, churches, meteorological stations, etc. and given into the care of those capable of restoring them to normal conditions of level and adjustment from time to time at regular intervals of inspection. The observers should be instructed as to a set manner of adjusting the seismoscopes and of checking the effects of an earthquake upon them.

Besides these cheap instruments there should be recording seismographs at various points in the seismic area. These should be capable of withstanding the shocks to which they are likely to be subjected, and of recording the various effects of these shocks—their period, amplitude, acceleration, and duration.

There is a real need for a reasonably priced instrument, perhaps such as that recently devised by Prof. K. Suyehiro as reported in the following papers:

(*a*) "On the Nature of Earthquake Motions Examined by a Seismic Vibration Analyser," *Proceedings of the Imperial Academy of Japan*, Vol. 2, No. 6, Tokyo, June, 1926.

(*b*) "A Seismic Vibration Analyser and the Recording Obtained Therewith," *Bulletin of the Earthquake Research Institute, Tokyo Imperial University*, Vol. 1, 59-64, August, 1926.

(*c*) "On the Nature of Earthquakes Studied by Means of the Seismic Wave Analyser," *Bulletin of the Earthquake Research Institute, Tokyo Imperial University*, Vol. 7, Part 3, 467-470, December 1929.

Seismographs designed to record the acceleration of an earthquake movement are desirable. It is quite possible to make instruments capable of registering such a record and of continuing to operate throughout a severe earthquake.

It should be possible to inaugurate such a complete field investigation for an area of frequent earthquakes. The experience gained would tend to indicate the most efficient and economical means of preparing for the investigation of the less-frequently disturbed seismic areas. The result obtained would be of inestimable value in pure seismology and also in its applications to engineering and insurance.

APPENDIX A.

The Rossi-Forel Scale of Earthquake Intensity*

(1) Recorded by a single seismograph or by some seismographs of the same pattern, but not by several seismographs of different kinds; the shock felt by an experienced observer.

(2) Recorded by seismographs of different kinds; felt by a small number of persons at rest.

(3) Felt by several persons at rest; strong enough for the duration or direction to be, appreciable.

(4) Felt by several persons in motion; disturbance of movable objects, doors, windows creaking of floors.

(5) Felt generally by everyone; disturbance of furniture and beds; ringing of some bells.

(6) General awakening of those asleep; general ringing of bells; oscillation of chandeliers, stopping of clocks; visible disturbance of trees and shrubs; some startled persons leave their dwellings.

(7) Overthrow of movable objects, fall of plaster, ringing of church-bells, general panic, without damage to buildings.

(8) Fall of chimneys, cracks in the walls of buildings.

(9) Partial or total destruction of some buildings.

(10) Great disasters, ruins, disturbance of strata, fissures in the earth's crust, rock-falls from mountains.

APPENDIX B

Previous Seismic Record of the Saint Lawrence Valley

Persistent investigation of every indicated source of information of historical references to the seismic conditions in Quebec has yielded, to date, a list of some 325 earthquakes which have taken place during the past 300 years in Eastern Canada and in New England. Special mention may be made of the following earthquakes, all centering in Eastern Canada, and comparable in intensity with the shock of 1925. They are as follows: February 5, 1663; September 5, 1732; December 6, 1791; October 17, 1860; and October 20, 1870. Adding the quake of 1925 we have a list of six earthquakes arranged roughly at five (taking account of the 1860 and 1870 shocks coming so close together that they may be counted as one place in the cycle) intervals of about 60 years. The earthquake of 1663 (see "The Probable Epicentre of the Saint Lawrence Earthquake of February 5, 1663". *Journal of the Royal Astronomical Society of Canada.* Vol. 22, No. 8, 325-334, October, 1928) may have been worse than any of the others, or it may be that accounts were exaggerated because of the difficulties involved in investigating reports received at the scattered posts. None of the others, unless perhaps it may be that of 1860, seems to have been less severe than that of 1925.

* *From "A Manual of Seismology," by Charles Davison, Cambridge University Press, 1921. (A bibliography of this scale is there given: it was published first in 1883).*

The following notes with regard to each of the five earthquakes mentioned in the preceding paragraph will serve to indicate the nature of each and also the various sources of information.

February 5, 1663

Although a most severe earthquake occurred on this date it was but one of a series which terrified the early settlers and the Indians during the spring and summer of 1663. The accounts, as reported in various publications, are based for the most part on two records, namely:

"Histoire et description générale de la Nouvelle France avec le journal historique d'un voyage fait par ordre du roi dans l'Amérique septentrionale." Pierre François Xavier Charlevoix, S.J., Paris, 1744.

"The Jesuit Relations and Allied Documents, Travels and Exploration of the Jesuit Missionaries in New France, 1610-1791" (Presented in the original French, with the English translation on facing pages throughout 75 volumes). Edited by Reuben Gold Thwaites, Secretary of the State Historical Society of Wisconsin. Published by the Burrows Brothers Company, Cleveland, Ohio. Edition limited to 750 sets. A complete set may be found in the reference room of the Carnegie Library, Ottawa.

The reference given in the section immediately preceding ("The Probable Epicentre, etc.") discusses the data available for study of this earthquake and presents the following conclusions:

"The study of the documentary evidence thus far would lead to certain tentative conclusions which are being critically examined in the light of each added bit of evidence. Although recited dogmatically in the following tabulation, they are not by any means completely established by the evidence to date. We are led to believe, however, that:—

"(1) The actual seismic intensity of the earthquake of February 5, 1663, was not incomparable with that of the disturbances of September 5, 1732; December 6, 1791; October 17, 1860; October 20, 1870; or that of February 28, 1925. That is to say, it was not markedly greater.

"(2) The documentary reports, while undoubtedly coloured by the excitement and terror of the early settlers, may be accepted to a much greater degree if we consider the possibilities of landslides.

"(3) Landslides are obviously aggravated by a previous wet season. It becomes, therefore, a matter of extreme importance to examine carefully all available accounts with a view to establishing the meteorological conditions in Canada during the fall of 1662. This evidence would have considerable bearing on the question of whether the reported disturbances (if real) were due to landslides or to unusually severe seismic tremors.

"(4) The reported devastation near Trois Rivières and in the valley of the Saint Maurice does not, in all probability, indicate a separate focus there, but was due to a landslide of major proportions in that valley.

"(5) There seems to be a reasonable basis for the assumption that the epicentre of the earthquake of February 5, 1663, lay below the city of Quebec, near that of the earthquake of 1925. We read, for example, from the writings of Francis Mercier (1665) that ' . . . Two highly trustworthy Frenchmen, who have traversed the whole coast of Malbaie (down to Tadoussac is indicated), made the assertion that the Relations of the year 1663 (Lalemant) had only half described the ravages wrought by the earthquake shocks of that region'."

At this point it would seem best to present an hypothesis regarding the reported disappearance of the waterfall at Les Grès on the Saint Maurice river between Trois Rivières and Shawinigan Falls which seems much more probable than any heretofore advanced. Indeed, it seems to offer a reasonable explanation of all the records of destruction in that valley by the earthquake of 1663. It was suggested by Mr. Julian C. Smith, of Montreal, who has made a very considerable investigation of the records of that earthquake.

We have only to accept the assumption that the original waterfall at Les Grès was of moderate proportions—15 to 20 feet in height or even a little more, which is not incompatible with the original accounts. It would offer, even so, a serious interruption to navigation and so would find place in the chronicles of voyages up the Saint Maurice. Below Les Grès, the banks of the river are more than 100 feet high. They are of clay and are subject to frequent landslides. The earthquake may be supposed to have caused slides of major proportions in this clay, which completely dammed the river, raising the water to a height sufficient to back up to the level of the top of the falls, thus temporarily "destroying" them. The clay in the river bed would provide the series of rapids which early writings indicate to have been found below the vanished waterfall.

This explanation finds support in the geology of the region, a support which has been lacking for any explanations previously offered. It agrees with the reports that the river "ran white with mud" for the following summer. It is in accord with the fact that, until a hydro-electric power dam was built in about this same position, and with the same effect of destroying the waterfall, such a waterfall existed in recent times at Les Grès, having been restored when the mud of the slides had been eroded.

September 5, 1732

The records of earthquakes in eastern Canada and New England were collected by the late Dr. J. W. (Sir William) Dawson and published in a series of papers which appeared in *The Canadian Naturalist and Geologist* as follows:

"A Chapter on Earthquakes", Old Series, Vol. 1, 189-196, May 1, 1856.

"Notes on the Earthquake of October, 1860", Old Series, Vol. 5, 363-372, October 17, 1860.

"The Earthquake of April, 1864", New Series, Vol. 1, 156-159, April 20, 1864.

"The Earthquake of October 20th, 1860", New Series, Vol. 7, 282-289, October 20, 1870.

In the Report Concerning Canadian Archives for the Year 1904 (4-5 Edward VII, Sessional Paper No. 18) on pages 176-178 the following references to the earthquakes are given:

1733: April 21 . . . . . Is happy that the earthquake felt in Montreal did not do much damage to the town walls. (pg. 176)

1733: May 6 . . . . . Does not think the damages of the earthquake in Montreal were large enough to be worth aiding. (pg. 178)

1735: April 12 . . . . . Cannot grant to the Recollets the sums they ask for the losses suffered by them during the earthquake. (pg. 212)

In the second of the four lists published by Sir Wm. Dawson, he states: "1732, September 5, Canada, New England, and as far as Maryland, buildings injured."

A paper entitled "Les tremblements de terre de Québec," was published by Mgr. J.-C. K. Laflamme, (Proceedings and Transactions of the Royal Society of Canada, Third Series, Vol. 1, Section IV, 157-183, Ottawa, May, 1907). He presents the following note with regard to the earthquake of 1732: "Le séisme de 1732 n'ayant affecté que la région de Montréal ne rentre pas rigoureusement dans le cadre de ce travail. Nous en dirons quelques mots cependant pour faire voir que, si les séismes montréalais ont, en général, moins d'intensité que ceux de la région inférieure de la province, ils peuvent cependant atteindre un certain degré de violence.

"La Mère Duplessis de Sainte Hélène, supérieure de l'Hôtel-Dieu de Québec, après avoir parlé, dans une lettre du 20 octobre 1732, de l'incendie de Montréal qui avait détruit 190 "corps de logis," ajoute: 'Depuis un mois c'est un tremblement de terre qui y jette une consternation qu'on ne peut exprimer. De la première secousse qui ne dura que deux ou trois minutes, plus de trois cents maisons ont été endommagées, quantité de cheminées tombées, des murailles fendues, des personnes blessées, une fille tuée, des grêles de pierres qui se répandaient partout et qui semblaient être jetées par des mains invisibles, enfin un effroi si universel que les maisons sont désertes, on couche dans les jardins, les bêtes même privées de raison jetaient des cris capables de redoubler la frayeur des hommes. On fait des confessions générales de tous les côtés: les dames ont quitté leurs paniers, les prêtres leur ont fait signer une promesse. Plusieurs ont fui et sont venus à Québec pour n'être enseveli sous les ruines de cette pauvre ville. Le fâcheux est que tout celà n'est pas fini. Il n'est point de jour qu'il ne se fasse sentir; il y a des puits qui ont été extrêmement taris, des chemins boulversés.'

"D'autre part, l'ingénieur de Léry écrit au ministre pour lui annoncer qu'il y a eu un tremblement de terre à Montréal. Le 3 octobre 1732, l'intendant Hocquart apprend au Ministre la nouvelle de ce tremblement de terre, et, le 12 avril 1735, le Président du Conseil de Marine écrit à l'intendant Hocquart qu'il ne peut accorder aux Récollets la somme qu'ils demandent pour les pertes subies par eux dans le tremblement de terre."

It is desirable that further references to this earthquake be sought, in order that it may be established whether an earthquake of such intensity centred near Montreal or, if not, the position of its epicentre.

The fact that the first tremors lasted "only two or three minutes", would indicate that Montreal was not the centre of this earthquake. It is just possible that later references. may establish an epicentre much farther down the Saint Lawrence.

December 6, 1791:

The paper by Mgr. Laflamme, quoted in the case of the earthquake of 1732, has the following note regarding the earthquake of 1791: "Le tremblement de terre de 1791 fut un de plus violents qui ait jamais été ressentis dans notre région. C'est surtout dans le comté de Charlevoix qu'il fit les plus grands ravages. Nous avons l'avantage de posséder le récit d'un témoin oculaire de ce terrible phénomène. Au moment de la catastrophe, ce témoin,—une fillette,— avait douze ans. Plus tard, sur la fin de sa vie, elle écrivit ses notes et l'abbé A. Mailloux les a insérées telles quelles dans son 'Histoire de l'Île-aux Coudres' publiée en 1879. En lisant ce récit que nous reproduisons plus loin, on verra que la jeune personne savait observer avec une rare perspicacité, car les détails qu'elle nous donne sont en parfaite conformité avec ce que l'on sait se passer dans tous les tremblements de terre un peu violents . . . . . "

Then follows an account covering five closely printed pages and detailing the effects of the earthquake. A map is included. The centre of the earthquake is given as the lower Saint Lawrence—Baie Saint Paul, Malbaie, and the vicinity. The last paragraph of the quotation may be given in full, followed by the comments of Mgr. Laflamme in concluding his references to the earthquake: " 'Plusieurs vieillards remarquent que depuis plusieurs quarts de siècles, il y a eu des tremblements de terre semblables à celui-ci qui ont duré quarante jours. On trouve que leur retour est passablement exact de 25 ans en 25 ans à une année ou deux de variation et que le présent est le troisième qui, à leur souvenir, est arrivé dans la même saison, à la différence d'un mois ou deux.'

"A ce propos, nous nous permettrons d'ajouter que, depuis 1791, les paroxismes séismiques semblent se répéter plutôt tous les quarante ans, ou à peu près. Si cette règle était vraie, nous devrions nous attendre à avoir des perturbations plus violentes que celles de tous les jours vers 1911. On peut cependant en douter, car ces répétitions périodiques à dates précises, sont toujours très incertaines."

If we limit the earthquakes included in a deduction of the cycle period to those which were felt over Eastern Canada and New England we have the following, according to the card index of earthquakes for this region on file at the Dominion Observatory. (There is some evidence of a great earthquake in 1534 or 1535, which is added for what it may be worth.)

Date of Earthquake	*Interval*
1534–35	
	129 years
1663	
	69 "
1732	
	59 "
1791	
	69 "
1860	
	10 "
1870	
	55 "
1925	

The evidence seems to indicate a cycle greater than 25 or even 40 years. There is, however, evidence of periodicity of a sort. If prediction is ever to be safe for this region it must be based on a long-continued study of the fore-shocks and after-shocks of one of the great quakes. Immediately following the earthquake of 1925, steps were taken to establish a seismograph in the region of Sainte Anne de la Pocatière, with the object of recording the after-shocks of the earthquake and to continue the observations. It was soon found that the instrument used was not suited for such work. Since then, two stations, using instruments specially designed for recording local shocks, have been established in the province of Quebec, one near Shawinigan Falls, the other near Beaupré, for the purpose of recording the shocks which affect eastern Canada, the Sainte Anne station being discontinued. To completely fulfil the purpose for which they have been established, it will be necessary that the observations be continued up to and beyond the next great shock. When it will occur, we cannot tell. It would at least seem a fair assumption that it will not be later than 70 years after the last one, that is to say, before 1995. It is possible that it will happen much sooner than that.

October 17, 1860

The best account of this earthquake is that given by Sir William Dawson in the second of the papers to which reference was made on page 429. He writes: "On the 17th October, Canada and the Northern States of the American Union were visited by an earthquake vibration of a more general and impressive character than any that has occurred for many years, and we propose to present to our readers such reports as have reached us with respect to its distribution, time, and local intensity, and to add for comparison and future experience a summary of the earthquakes that have occurred in Canada since its colonization, and some remarks on the laws of these phenomena as far as they have been ascertained.

"In Canada the earthquake of the 17th was experienced in its greatest intensity in the lower part of the river, and with diminished force as far west as Hamilton. In the United States, in like manner, it was most violent on the Atlantic coast and extended westward apparently with less intensity as far as Troy. Between Hamilton and Father Point it was felt throughout the whole of (Upper and Lower) Canada. At Rivière Ouelle and other places in the lower Saint Lawrence it was so violent as to throw down chimneys and damage walls, and several severe shocks were felt. In Upper Canada there appears to have been but one shock and this comparatively feeble. We have at present no information as to the extension of the vibrations to the north of Canada and to the south of the Northern States. (It was felt in New Brunswick also.)

"The following list of places in which observations were made of the time and intensity of the shocks has been compiled chiefly from the newspapers, to which much credit is due for the careful and intelligent manner in which they have collected and recorded the facts.

"The places have been arranged in the order of their longitudes from east to west, and it will be observed that the time is earlier in eastern localities, but on comparing

Bic and Belleville nearly nine degrees of longitude apart, it will be seen that the difference of time is only a little less than that due to the difference of longitude. The Hamilton observation would give an earlier time, but as the shock was slight and the testimony of only one observer was recorded there may be an error. The shock thus appears to have been nearly simultaneous throughout Canada." (In view of the velocity with which the seismic tremors are propagated and the evidently inaccurate time checks used, this conclusion is not warranted—E.A.H.)

Then follows a list of reports from Bic to Hamilton. The author continues: "The following graphic account of the phenomena as observed at Rivière Ouelle appeared anonymously in a Quebec paper, and is the most detailed statement we have seen of the effects of the earthquake in those localities in which it was most evident.

Rivière Ouelle, 17 octobre, 1860

'Ce matin trois fortes secousses de tremblement de terre sont venues jeter la frayeur au milieu de nos populations.

'Les bâtisses situées de chaque côté de notre rivière ont souffert généralement. Une cheminée chez E. Chas Tetu, deux chez M. C. Casgrain, une chez M. Frenette, une chez Auguste Casgrain, une chez Madame Frs Casgrain, et chez une dizaine d'autres personnes ont été renversées. La croix de notre église et le coq qui la surmontait sont à terre; *les murs de notre belle église sont lézardés.* Les secousses étaient effrayantes, la première, la plus violente, a commencé à six heures et quart et a duré quatre minutes et 40 secondes, très violente durant dix secondes et s'affaiblissant graduellement; la secousse la plus faible à six heures et vingt minutes, a duré trois à quatre secondes, et la troisième a commencé à six heures et demie, et n'a duré que deux à trois secondes; mais, comme la première, c'était un choc saccado faisant danser les meubles, décrochant les cadres, les horloges, etc.

'*Les secousses ont été plus faibles sur les hauteurs, que dans les plaines,* de sorte que mes bâtisses se sont trouvées à l'abri des accidents.

'Jamais de mémoire de nos habitants, nous n'avons eu des coups aussi forts. Je suis demeuré devant mon horloge tout le temps pour m'assurer de sa durée, afin de pouvoir computer avec d'autres endroits la marche de ce grand et terrible phénomène.

'Un bruit sourd et fort nous a d'abord averti et ensuite sont venus les secousses et les craquements.'* . . . . . "

The author continues with observations about earthquakes in general and the one of 1860 in particular and finally gives a list of earthquakes felt in Canada and New England since colonization.

The italics in the above French quotation are inserted to mark two comments which are of interest in view of the observations in the case of the earthquake of 1925. The church,—*notre belle église,*—whose walls were damaged in 1860 was presumably rebuilt. The one wrecked in 1925 had been built in 1872, indicating that it was again wrecked in the earthquake of 1870. Yet in 1925 it was again rebuilt in the same spot, of the same stone, in the same design,—and with every prospect of having the same destiny.

The second part italicized in the quotation was so printed to draw attention to the fact that, as in 1925, the disturbance differed markedly in intensity on the heights to the south and in the plains beside the river.

October 20, 1870

The earthquake of 1870, as described by Dawson in the last of the four publications mentioned on page 429, was less severe than that of 1860 except at Baie Saint Paul and, presumably, nearby points. Except for one rather lengthy description by the parish priest of Baie Saint Paul the reports of the earthquake effects are short. The tremors were felt over the whole of Eastern Canada and New England, as far west as Sault Sainte Marie, the north shore of lake Superior, and Dubuque, Iowa. It was felt as far south as Richmond, Va.

A detailed account of meteorological conditions at the time of the earthquake at various points in Canada is furnished by Dr. Smallwood of McGill University, Montreal.

Three direct quotations may be given:

"As usual with Canadian earthquakes, this was felt most severely in the Lower Saint Lawrence, more especially at the junction of the Lower Silurian and Laurentian formations in the vicinity of Baie Saint Paul, Malbaie, and the Saguenay."

"Other correspondents mention the opening of chasms in the ground, from which streams of water and sand burst forth. This phenomenon arises from the landslips produced in the terraces of post-pliocene clay which in that part of the country rest against the steep sides of the Laurentian hills. These are ready to slide downward with any slight movement of the earth, and to press the water out of the sandy layers associated with them or give outlet to hidden springs and streams."

"It is also stated that a mass of rock 400 feet in length fell from the face of the cliff at Cape Trinity, in the Saguenay. Cape Trinity is a cliff of Laurentian gneiss, presenting to the river a vertical front abour 1,500 feet high." (Capes Trinity and Eternity are on either side of the mouth of Eternity river which flows into the Saquenay about 30 miles above the confluence of the Saguenay and Saint Lawrence rivers.) The article by Mgr. Laflamme (*see* page 430) devotes 5 closely printed pages to a description of this earthquake.

Besides the greater earthquakes of 1663, 1732, 1791, 1860, 1870, and 1925, there have been some outstanding shocks during historic times which were of secondary, though still considerable, intensity, or which appear to have centred off the Atlantic coast, and which were felt over considerable areas in Eastern Canada and New England. Without going into details for these records, it may be of value to record the dates on which they occurred. The complete index includes, at the present date, a total of 242 earthquakes up to and including the one of 1925 (but not its after-shocks) of which the following (in addition to the ones discussed in detail) were strongly felt over considerable areas:

Date	*Remarks*
1534–35	Les Eboulements, Que. reported to have been so named from the effects of an earthquake which occurred between the two voyages of Jacques Cartier.
1638	Eastern Canada and New England, apparently with centre in Canada.
1727, Nov. 9	Centred near Newbury, Mass. and followed by after-shocks which continued for nearly a year.
1755, Nov. 18	New England and Eastern Canada, particularly Nova Scotia. Felt as far south as Maryland. 1,200 chimneys destroyed in Boston. Epicentre may have been under ocean.
1831, July 14	Malbaie, Beauport, Kamouraska. Houses damaged. (One authority reports very similar details for an earthquake on May 7-8 of the same year: it is not certain whether there were two dates of shock or not.)
1842, Nov. 8–9	Montreal and Trois Rivières.
1864, April 20	Felt over considerable area in Eastern Canada. Reported in a special paper by Sir Wm. Dawson.
1897, March 23	Montreal, over Eastern Canada and New England. This was the first earthquake registered in Canada according to McLeod and Callendar. Felt over an area 300 miles by 100 miles.
1904, March 21	Felt over about 300,000 square miles. Eastern Canada and New England.
1924, Sept. 30	Widely felt over Eastern Canada and New England. Located at practically the same epicentre as that of 1925.

The references consulted in preparing the card catalogue of earthquakes in Eastern Canada and New England have been brought to the attention of the writer by many individuals at various times. There have been three outstanding sources, however, to which reference should be made:

(*a*) The bibliography and catalogue entitled "The Earthquake Record in New England," prepared by Hollis Godfrey, Kirtley F. Mather, and Katherine Hampson, presented as a paper at the Second Annual Meeting of the Eastern Section of the Seismological Society of America, and published by the Engineering Economics Foundation of Boston. The bibliography, as furnished the writer by Dr. Mather, in manuscript form, lists 56 references. The catalogue tabulates the Year, Day, Hour and Minute, Epicentre, Intensity (on Rossi-Forel scale) at Epicentre and at Boston, Limits of Appreciably Shaken Area, and Sources of Information.

(*b*) Notes and records by the late Professor Woodworth of Harvard University, who, for many years, made a continued study of the records of earthquakes in New England. The bibliography compiled from his notes furnishes 15 additional references.

(*c*) The "Earthquake History of the United States, Exclusive of the Pacific Region," by N. H. Heck. Special publication No. 149 of the U.S. Coast and Geodetic Survey, Washington, D.C. Comdr. Heck lists a total of 28 references, only a few of which are included in the two sources (*a*) and (*b*).

In concluding his paper on "Les Tremblements de Terre de Québec," Mgr. Laflamme writes: "De ce trop long travail nous nous permettrons de tirer une conclusion pratique. Étant donné l'âge très ancien de nos terrains québécois, il n'y a aucune raison de craindre qu'ils soient jamais le siège de perturbations séismiques violentes, comparables à celles des régions séismiques proprement dites. Nous n'aurons donc guère au Canada que ce que l'on pourrait appeler des tremblements de terre de laboratoire. Mais cela n'enlève aucun intérêt à leur étude.

"Par conséquent, l'installation de séismographes à la Baie Saint Paul ou quelque part dans les environs, donnerait des renseignements de la plus haute valeur, surtout si les appareils inscrivaient la composante verticale en même temps que les composantes horizontales.

"L'entreprise vaut d'être tentée, et nous soumettons respecteusement cette suggestion aux fervents de la science séismique. On arriverait ainsi à faire une étude aussi complète que possible de nos tremblements de terre et à déterminer à la fois, et la position exacte de la ligne épicentrale, et sa profondeur au-dessous de la surface du sol."

Some small start has been made toward this instrumental investigation of the seismicity of Quebec. As has been indicated on page 432, short-period seismographs are now operating under ideal conditions at two points in Quebec. At present only one component, short period, horizontal instrument is installed at each station. As advocated by Mgr. Laflamme, it would be desirable to have both horizontal components and also a vertical at each station. For the present, all that can be determined is the number of small shocks occurring in the province and their relative intensity. Some slight indication is also given of their location. To obtain all the information desired it will be first necessary to perfect the time-recording arrangements and then to add the other horizontal component and the vertical at each of the stations. The seismic history of Quebec, as sketched in this appendix, serves to show that there is a field of investigation here which, when fully and carefully cultivated, should yield much valuable information in seismology, pure and applied.

DOMINION OBSERVATORY,
OTTAWA, August, 1930.