Seismological Investigations.—Sixteenth Report of the Committee, consisting of Professor H. H. TURNER (*Chairman*), Mr. J. MILNE (*Secretary*), Mr. C. VERNON BOYS, Sir GEORGE DARWIN, Mr. HORACE DARWIN, Major L. DARWIN, Dr. R. T. GLAZEBROOK, Mr. M. H. GRAY, Mr. R. K. GRAY, Professor J. W. JUDD, Professor C. G. KNOTT, Professor R. MELDOLA, Mr. R. D. OLDHAM, Professor J. PERRY, Mr. W. E. PLUMMER, Mr. CLEMENT REID, Professor R. A. SAMPSON, *and* Professor A. SCHUSTER. (*Drawn up by the Secretary.*)

[PLATES I. AND II.]

CONTENTS.

I. *General Notes.*

THE Committee seek to be reappointed with a grant of 60*l*.

Registers.—During the last year Circulars Nos. 22 and 23 have been issued. They refer to Shide, Kew, Bidston, Edinburgh, Paisley, Eskdalemuir, Guildford, Stonyhurst, West Bromwich, Haslemere, San Fernando, Ponta Delgada, Toronto, Victoria, B.C., Beirut, Cairo, Valletta, Cape of Good Hope, Bombay, Kodaikanal, Colombo, Honolulu, Perth, Sydney, Wellington, Christchurch, Baltimore, Mauritius, Cape Verde, Ascension, Calcutta, and Adelaide.

Visitors.—During the last year many people visited the observatory at Shide. Among those who came for instruction or to obtain special information were the following: Prince B. Galitzin; G. Raymond, H.M. Consul at Corfu; Professor B. Mano, of the Earthquake Investigation Committee of Japan; Professor H. H. Turner; J. Woodrow, Coats Observatory; P. J. Hood, Eastern Telegraph Company; M. H. Gray; T. Chance, Cardiff; Professor J. Swain, Cork University; G. H. Harrison, in connection with Tidal Load instrument at Ryde; Colonel G. Elliott, R.E.; W. E. Jenkin, Rio Tinto Mines, Spain; Sir Daniel Morris, who has given assistance in establishing an instrument in the West Indies; W. G. Freeman, Trinidad; F. H. Longhurst, Deputy Director of Public Work, Accra; Members of the Science Section of the Bournemouth Natural History Society; B. F. E. Keeling, Cairo.

Seismological Exhibition.—At the suggestion of the Science Committee of the Coronation Exhibition at the White City, I organised a Seismological Section. This Committee communicated with most of

our Colonies and with individuals and institutions in Great Britain, with the object of obtaining exhibits. Mr. M. H. Gray sent a large map of the world, 30 feet by 15 feet, which shows stations co-operating with the British Association and the centres of marked seismic activity. I sent a tidal-load recording instrument made in Newport, and through Mr. R. W. Munro, a British Association type of seismograph. The Rev. Father W. O'Leary forwarded a model of a new type of seismograph which he is using at the Mungret College, Limerick. In the Machinery Hall, Mr. J. J. Shaw, of West Bromwich, erected a pair of horizontal pendulums which, notwithstanding the varying loads and vibrations to which they are subjected, have recorded several large earthquakes. These with other instruments, enlargements of seismograms and various pictures, constitute the chief features amongst the exhibits. I mention this matter because it is the first exhibition of its kind in this country, and also because it has done very much to call attention to a new science.

New Stations.—Mr. W. Davis, Director of the Meteorological Office, Argentina, is establishing at least three new stations at which the British Association type of instrument will be used. Another instrument is to be established at the University of Cork, and one at Cardiff is now in working order. The instruments despatched last year to Cape Verde, Ascension, Fernando Noronha, and St. Helena have been installed and records are being obtained from these places. Those sent to the Seychelles, Cocos, and Fiji have arrived at these places and we may shortly expect to receive records from the same. I may here mention that the instrument at Fernando Noronha, like the one at San Fernando in Spain, was purchased for our benefit by Mr. Robert K. Gray. The instrument purchased by the Pacific Cable Company to be used at Fanning has not yet reached that island. The reason for the delay is that an officer from that island has not been in England to receive instructions, and it is seldom that the island is visited.

The Colonial Office have kindly sent out circulars to Governors and other officers in Colonies bordering the Eastern and Western sides of the Atlantic inviting them to co-operate in the seismological work of the British Association. These include Newfoundland, Bermuda, Barbados, Jamaica, and Turks Island; other islands in the West Indies, Guiana, Honduras, the Falklands and the Gold Coast. Mr. Joseph Rippon of the West India Cable Company has given great assistance towards the furtherance of this object.

On March 28, 1911, the Legislative Council of Bermuda passed a 'Seismographic Act' enabling the Board of Public Works to purchase and maintain a seismograph.

On behalf of the International Seismological Association I have sent out to stations co-operating with the British Association a circular which states that the Central International Bureau at Strasburg is prepared to test earthquake instruments. These tests will be made free of cost for stations in countries which have joined the International Association, but for others there will be a charge of from 100 to 150 marks. An enclosure with this circular asks for material to complete a macroseismic catalogue for 1907.

II. *Double and Multiple Earthquakes.*

Attention has frequently been drawn to the fact that an earthquake as it radiates may cause a collapse of strata which are in an unstable condition and thus give rise to one or more secondary disturbances.[1] The great earthquake of Lisbon in 1755 gave rise to secondary shocks in England and Ireland, and probably in many other countries. In the volume containing Physical Observations made in the Antarctic Regions in 1902-03, published under the superintendence of the Royal Society, page 92, I gave illustrations of secondary earthquakes the genesis of which corresponded in time to the arrival of certain phases of primary disturbances. That the large waves of a seismic disturbance as they travel round the world causing the crust of the same to rise and fall like a raft on an ocean swell should give rise to one or more secondary disturbances is not surprising. Further than this, any of the latter which may be *greater or less than* their parent may in turn become the originator of further settlements. One megaseism may therefore cause a relief of seismic strain throughout the world. An indication of this is seen in the fact that large earthquakes originating in widely separated districts frequently occur in groups. This idea I wish to extend to the possibility of secondary earthquakes originating in consequence of mass displacement or 'push' exerted in a hypofocal region, or on the arrival of waves of the type P_1 and P_2, the speeds of which are relatively about four times and twice those of P_3. This means that an earthquake originating at A might result in reliefs of strain in distant localities B, C, D, &c., on the arrival of P_1 which radiated from A. The seismograms obtained at stations near to B, C, D would on account of the differences in the times of arrival of P_1 at these places coinciding with what we should expect, be attributed to the primary impulse originating at A and not to impulses which had been brought into existence in the neighbourhood of B, C, and D. Generally this supposition is correct, but instances occur where it fails to explain the amplitudes of movement and the times of arrival of P_3 or the maximum movement recorded at these latter stations. It has been shown that stations at great distances from the origin of a megaseism may record movements which have travelled to them in opposite directions round the world. This might, at a distant station, give rise to at least two maxima and a lengthening of the duration of motion. These phenomena may also find a partial explanation in the hypothesis of reflections within our world, or the echoes from mountain roots.[2] What I now suggest is that these unexplained characteristics of certain seismograms may partly be the outcome of secondary disturbances the existence and importance of which has hitherto been unrecognised.

Example 1.—*Guatemala Earthquake, April* 19, 1902.

On April 19, 1902, a violent earthquake took place in Guatemala. It partly obliterated Quezaltenango, Amititlan, and badly damaged many other places. It was accompanied by fires. If it could be shown that the fires broke out before the earthquake certain fire insurance companies were liable. On the other hand, if the fires occurred with or

[1] See *Earthquakes*, 'International Science Series,' p. 248.
[2] See *Brit. Assoc. Reports*, 1899, p. 227; 1900, p. 71

immediately after the earthquake and could therefore be regarded as a consequence of the same, the companies were free from liability. The result was that a careful inquiry was instituted as to the exact time of the earthquake. This involved consultations with observatories near to and at great distances from the stricken district as to the exact time at which the earthquake had taken place. The result of these investigations was that 2.22 P.M. in G.M.T. was adopted as the time of the disaster, but from information received since this inquiry, I am led to think that a safer estimate is 2.21 $\pm$ 1 minute.

The records taken at stations all over the world, if we only consider the times at which the first motion or P_1 was noted, lead with certain variations to the same conclusion. Observatories in all the continents rightly concluded that their records referred to the Guatemala earthquake, but the idea that these records might also refer to several other earthquakes does not appear to have been considered.

We expect maxima to recur at regularly spaced intervals when the period of the pendulum approximates to that of the ground. Recurrences of maxima at varying intervals which we have here to consider suggest a variable period in the movement of the ground. Although this supposition may be true, it does not preclude the idea that accretions of activity may arise from the generation of secondary disturbances.

Mr. R. D. Oldham, who has made a careful study of this earthquake (see Proceedings of the Royal Society, vol. 76) writes to me as follows: 'It seemed as if the well-defined maximum at 90° to 100° was due to the combined effect of a group of waves, the faster travelling having caught up the slower at about that distance, and these as they travelled on separated again giving a long drawn out seismogram with no defined maximum but a series of bulges, due partly to interference of the waves travelling at different rates and partly to interference between these and the swing of the pendulum.'

With regard to this earthquake we know that it originated about 2.21, and records from stations on the American continent, whatever phase of motion we consider, support this conclusion. Very distant stations from Guatemala, however, only fall in line with this so far as P_1 is concerned. This first maximum recorded at Capetown 2h. 58m., Calcutta 3h. 13m., Bombay 3h. 8m., Kodaikanal 3h. 6m., and Perth 3h. 4m., apparently refers to an epicentre in the Indian Ocean, which lies about 60° East and 35° South, and not to Guatemala. This disturbance originated at about 2h. 34m. The second maximum at Capetown 3h. 26m., Bombay 3h. 43m., Kodaikanal 3h. 52m., and Perth 3h. 4m., approximately accords with Guatemala. The difference in time between the Guatemala shock and the one in the Indian Ocean is about fourteen minutes. The time taken for a compressional wave to travel between these two origins, or 146°, would be about 21m. This being so, unless we admit an error of six or seven minutes in one of these time determinations, which might easily be the case, we cannot say that the second earthquake was brought about by compressional waves from Guatemala. A relationship is not proven, it is only suggested. First of all it may be noticed for this earthquake, and also for others, that the ground moved for a longer time at very distant stations from the epicentre than it did at stations which were comparatively near to the same. At Baltimore, Toronto, Victoria, Cordova, Edinburgh,

Bidston, San Fernando, Shide, and Kew, the distances of which from the epicentre lie between 27° and 79°, the average duration of movement was 2h. 32m.; whilst at Christchurch, Tokio, Irkutsk, Capetown, Calcutta, Bombay, Perth, Kodaikanal, and Batavia the epicentral distances of which lie between 104° and 160°, the average duration was 2h. 51m.; the durations for Capetown and Christchurch were respectively 4h. 52m. and 3h. 19m.—the longest recorded in the world. One explanation for these observations is the assumption that the flood of motion set free in Guatemala had been augmented as it travelled.[1]

Amplitudes point in the same direction. At Wellington, New Zealand, the pointers were driven off the recording surface, and the seismogram suggested that the earthquake had originated near to that place rather than in Guatemala, which is 103° distant. Although this particular record is exceptional, the seismograms from quadrantal regions do not exhibit the great falling off in amplitude which we should anticipate.

Another indication of reinforcement is in the repeated maxima seen in seismograms obtained at different stations.

The records from Manila 2.46, Tokio 2.51, Irkutsk 2.51, and Wellington 3.39 may be explained by the assumption that at about 2.36 an earthquake originated at 113° E. and 27° N.

The Wellington maximum which exceeded 15 min., it will be observed, roughly agrees with each of the three epicentres which have been considered—that is to say, maxima movements from three centres reached Wellington at nearly the same time.

All the observations to which I have referred were made with similar installed instruments.

Example 2.—*The Arica Earthquake, December* 26, 1906.

On December 26, 1906, at 5.56 A.M. G.M.T., an earthquake wrecked several houses in Arica and was felt severely in Iquique and Pisagua. From local observations and observations made in Cordova and Trinidad I should place the origin about 3° or 4° from Arica, and conclude that the disturbance originated a few minutes before it was recorded in that city. A certain number of minutes after the Arica earthquake seismograms were obtained at observatories in the West Indies, North and South America, Great Britain, Europe, Siberia, India, Australia, Batavia, China, Manila, and Capetown. These are more than fifty in number, and because their commencements are approximately at times we should expect P_1 to reach these various stations from an origin off the North coast of Chile, seismologists have attributed these various records to the Arica earthquake. They however indicate that the time at which it originated was at 5.51 or 5.52, which is about 2 min. earlier than the time I have just suggested.[2]

A close examination of these numerous records, however, shows that those relating to P_2, P_3, and, I may add, amplitudes, do not lead to the same conclusions as those derived from a discussion of those referring

[1] See *Brit. Assoc. Reports*, 1908, p. 72.

[2] *Ibid.*, 1907, p. 86, fig. 1323 on the map (Milne); *Bollettino della Società Sismologica Italiana*, Appendice, vol. 13, p. 511 (Martinelli); and the Publications du Bureau Central de l'Association Internationale de Sismologie, Catalogues 1906, p. 84 (Szirtes).

to P_1. Observations made in the Azores, San Fernando, Bidston, Shide, Messina, Rome, Tiflis, Colombo, and Irkutsk, point to an origin in the Atlantic about 18° W. and 38° N., which is not far from the Azores, where the amplitude was large. The time of the initial shock would be 6.4 ± 2 min., or approximately 12 min. after the Arica disturbance. Now the distance from Arica to the Atlantic origin is 75°, and this would be traversed by P_1 in 14 min. Although it may not be certain, it seems at least probable that the disturbance near to the Azores was brought into existence by the arrival of preliminary tremors which had originated off the western coast of Chile. A similar line of reasoning applied to the records from Honolulu, Batavia, and a second maximum seen in the Irkutsk seismogram suggests that a third disturbance had taken place in mid-Pacific.

Other Examples of Multiple Earthquakes.

In the following list I give the date and times at which these occur; after that the longitude and latitude of their origins and the distances that these are apart expressed in degrees. Lastly, I give the time we should expect P_1, P_2, or P_3 to traverse the distance between any two origins and compare this with the difference in time between the occurrence of each pair of earthquakes.

Date	Time	Position	Distance	Time expected in minutes	Actual time in minutes
1899, July 11 .	7.29±3	140 E. 15 N.	132°	P_1, 9	7 ca.
	7.36±3	42 W. 35 N.			
1899, July 14 .	13.34±2	150 W. 60 N.	98°	P_1, 8	6
	13.40	33 E. 23 N.			
1899, Nov. 24 .	18.39	136 E. 5 N.	30°	P_1, 6	2
	18.41	132 E. 33 N.			
1900, Nov. 9 .	16.7±2	96 W. 11 N.	112°	P_3, 70	106
	17.53	139 E. 34 N.			
1900, Dec. 18 .	22.4±2	125 W. 67 S.	83°	P_3, 53	71
	23.15±2	120 W. 27 N.			
1902, April 11 .	23.41	110 E. 50 N.	155°	P_1, 22	14
	23.55	65 W. 27 S.			
1902, Sept. 22 .	1.44	130 E. 30 N.	50°	P_1, 10	2
	1.46	175 E. 75 N.			
	1.56	152 E 52 S.	85°	P_1, 15	12
1902, Sept. 23 .	20.16	90 W. 15 N.	134°	P_1, 21	13
	20.29 ca.	77 E. 60 S.			
1902, Nov. 15 .	9.30	128 E. 20 N.	45°	P_1, 9	3
	9.33	105 E. 20 S.			
1903, Sept. 7 .	7.10	75 E. 71 S.	100°	P_1, 16	4
	7.14	122 E. 23 N.			
1903, Dec. 6 .	22.48	45 E. 41 S.	71°	P_3, 45	44
	23.32	31 E. 30 N.	Felt in Cairo		
1904, Oct. 9 .	13.51	15 W. 70 N.		P_3, 8	9
	14.0	Felt at Namdalen, Norway			
	14.15	Quito	81°	P_2, 24	24
1906, Mar. 27 .	5.0	55 W. 52 S.	156°	P_1, 22	23
	5.23	120 E. 78 N.			
1906, June 20 .	2.25	89 W. 13 N.	140°	P_3, 78	76
	3.41	121 E. 18 N.	Felt in N. Luzon		
1906, Aug. 17 .	0.6	168 E. 31 N.	132°	P_2, 32	35
	0.41	72 W. 33 S.			

III. *Seismic Activity in Japan, Italy, and America during the years* 1700-1900. By F. M. Walker, *B.A.*

With the object of finding, if possible, some well-marked synchronism between the periods of maximum seismic activity in the three widely separated districts, the following plan was adopted:—

An experimental period of eleven years was decided upon, and the total activity of each area during this 'undecade' was calculated. This was done by adding together the intensities of all destructive earthquakes recorded for that period. Thus, for example, 7 earthquakes of Intensity III, 13 of Intensity II, and 25 of Intensity I would give a total for the eleven years of 72. This divided by 11 gives the average activity for each year of that period, viz., 6.5. In this manner eighteen such averages were calculated for each area and plotted, see p. 37.

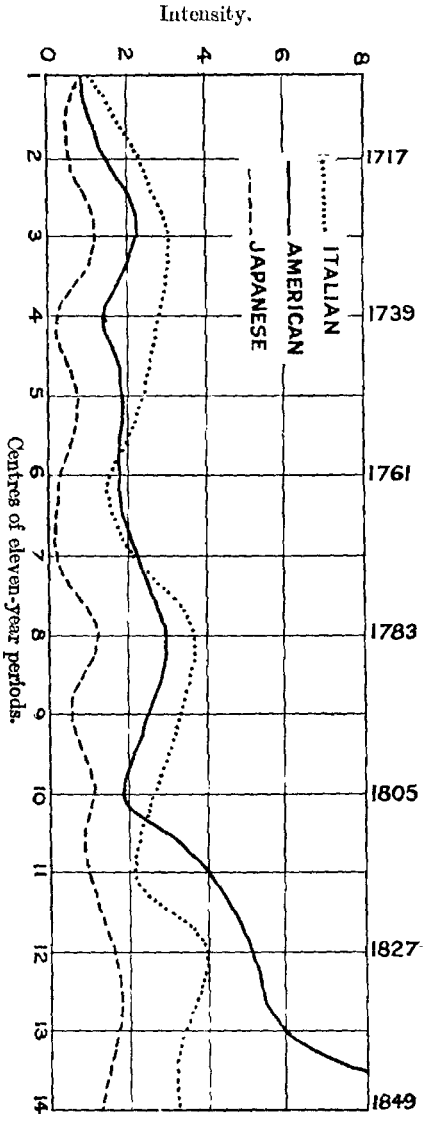
With regard to synchronism, the results were not very definite. The three curves show agreement at (1723-33), and again (1778-88), and in a less marked degree (1823-33). The curves for Japan and Italy show agreement at (1723-33), (1778-88), (1823-33), (1889-99) for a high average, and synchronic periods of declining activity for (1756-66), (1767-77), and (1812-22).

IV. *On the Synchronism of Seismic Activity in different Districts.*

In the British Association Report for 1908, p. 64, I pointed out that since 1902 seismic activity had fluctuated similarly on the East and West sides of the North Pacific. I returned to this subject in the Report for 1909, pp. 57 and 58, and showed that during the last three hundred years the times of activity in Italy, although separated from each other by irregular intervals, had varied between five and twenty years, and that these dates of activity in Europe closely corresponded to the dates when there had been marked activity in Japan. In consequence of additions which have been made during the last twelve months to a catalogue of destructive earthquakes of the world, I have been able to extend this inquiry and compare the times of earthquake activity or quiescence of the four following important but widely separated regions: the Italian Peninsula, including Sicily; Japan, Formosa, and the Philippines; North, South, and Central America; and China. The only earthquakes considered are those which have been destructive, and for brevity I refer to the four regions A, B, C, D.

The analyses only refer to the last two hundred years (1700-1899). The reason I have confined the examination to this particular period is that the records for the Philippines, and for the two Americas in particular, prior to the year 1700 are but few in number.

Because there has been an increase in the number of records kept in any given country as we approach modern times, but not necessarily an actual increase in the number of earthquakes which have taken place, to determine whether the number of records in a district for any


Intensity.
0
2
4
6
8
1
2
3
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5
6
7
8
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11
12
13
14
1717
1739
1761
1783
1805
1827
1849
ITALIAN
AMERICAN
JAPANESE
Centres of eleven-year periods.

given year represent an increase or decrease in activity, I have compared such numbers with the average number which took place in a certain period of years. The first average taken for all districts is for the years 1700 to 1734. For Italy this, for example, is found to be 1·7 per year. Any year during which more than two large earthquakes were noted is therefore a year in which seismic activity has been above the average. The remaining periods are each of thirty-three years, and respectively end in the year 1767, 1800, 1833, 1866, and 1899. The years in which these four widely separated districts, A, B, C, and D, have shown abnormal activity are the following: 1720, 1730, 1731, 1732, 1746, 1751, 1755, 1785, 1822, 1831, 1853, and 1885 (twelve times). There was comparative quiescence for all four districts in the years 1704, 1708, 1710, 1744, 1745, 1757, 1758, 1761, 1837, 1843, 1848, 1877, 1890, 1896, and 1899 (fifteen times).

Three districts have shown unusual *activity*, while there has been comparative quiescence in one in the following years: 1700, 1703, 1705, 1707, 1714, 1716, 1718, 1719, 1725, 1736, 1739, 1740, 1743, 1752, 1753, 1756, 1762, 1782, 1787, 1791, 1794, 1797, 1806, 1809, 1812, 1818, 1819, 1821, 1827, 1828, 1829, 1830, 1834, 1852, 1857, 1861, 1862, 1864, 1865, 1866, 1874, 1875, 1887, 1889, 1893, 1894 (forty-six times).

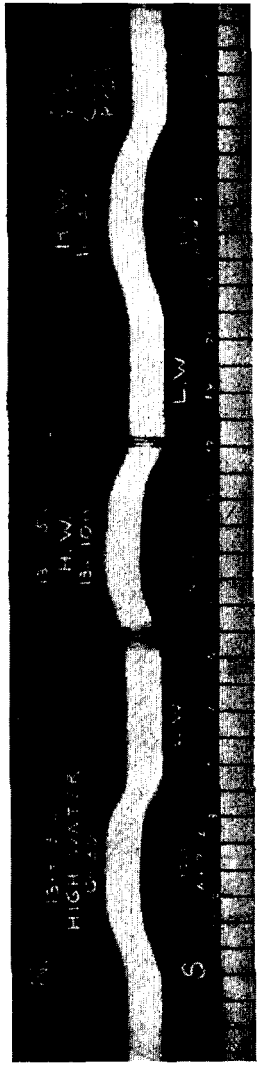
Three districts have shown unusual *quiescence* while there has been comparative activity in one, in the following years: 1701, 1709, 1712, 1728, 1733, 1734, 1737, 1738, 1741, 1748, 1750, 1760, 1764, 1768, 1769, 1770, 1772, 1773, 1777, 1778, 1781, 1788, 1793, 1798, 1799, 1801, 1803, 1804, 1805, 1807, 1810, 1813, 1816, 1817, 1820, 1823, 1824, 1835, 1836, 1838, 1839, 1840, 1841, 1844, 1845, 1851, 1860, 1863, 1867, 1869, 1879, 1880, 1883, 1884, 1886, 1895, 1897, and 1898 (fifty-eight times).

In all other years between 1700 and 1899 two districts have been active and two districts have been quiescent.

If the seismic activity or quiescence of three large districts out of four in the world is an indication that there has been unusual seismic activity or quiescence in the world generally, then the last two tables may be taken in conjunction with the two first. If we do this we see that, in 131 years out of 200, seismic activity or quiescence has generally been simultaneously in accordance in various parts of the world. In the remaining sixty-nine years the activity of two large districts has been balanced by the quiescence in two other large districts.

V. *Megaseismic Frequency.*

Between 1899 and 1909 the number of very large earthquakes recorded was not less than 976. Many of these were recorded at stations all over the world, others over the whole of the Northern Hemisphere, and none of them disturbed an area less than that of Europe and Asia.



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Illustrating the Sixteenth Report on Seismological Investigations.

The numbers recorded in successive months were as follow:—

Year	J.	F.	M.	A.	M.	J.	J.	A.	S.	O.	N.	D.	Total.
1899 .	9	5	9	4	3	6	7	7	12	4	7	4	75
1900 .	7	3	3	2	3	4	2	4	5	6	5	3	47
1901 .	7	4	8	4	4	3	0	8	6	6	11	6	67
1902 .	12	7	9	8	4	2	4	11	8	3	6	3	77
1903 .	10	11	7	4	8	8	5	5	8	9	6	10	91
1904 .	4	2	8	9	5	8	6	8	7	6	5	6	74
1905 .	7	11	10	7	6	8	11	3	7	6	5	5	86
1906 .	14	18	20	11	4	9	5	22	12	10	8	7	140
1907 .	8	4	9	6	12	9	7	7	5	10	10	7	94
1908 .	4	6	11	5	8	4	4	12	9	8	13	6	90
1909 .	9	10	11	14	11	14	8	13	13	15	8	9	135
	91	81	103	74	68	75	59	100	92	83	84	66	976
	275			217			251			233			

Winter months . . 508 } 976
Summer months . . 468 }

VI. *Observations on Tidal Load at Ryde, Isle of Wight.*

By the kind permission of the Committee of the Royal Victoria Yacht Club at Ryde I was allowed to instal an instrument, somewhat similar to the one at Bidston,[1] in one of their cellars. The room, which is about 12 feet below the surface, has a concrete floor. The column to support the instrument is a glazed earthenware drainpipe. At a distance of 138 feet from this on the north side, a sea wall forms the face of an outside veranda. With a spring tide the water rises against this to a height of 5½ feet. The same tide 1,508 feet further to the north, which is low-water mark, the depth of the water is about 12 feet.

From March 4 to April 8 the boom of the pendulum was oriented east-west, so that it recorded tilting of the ground in a north-south direction. It had a period of 15″ and 1° turn of the calibrating screw, which gives an angular deflection of 1″.9, caused the end of the multiplying lever to move 11 mm.; 1 mm. displacement on the photograms is therefore equal to 0″.17 of arc. The average ranges of tide at Ryde are from 9 feet to 13 feet.

A 10-foot tide results in a deflection of 0″.85 of arc. At Bidston a 10-foot tide gives at a distance of two miles a tilt of 0″.2. If the Bidston instrument had been installed within 150 feet of the sea the deflections might have been measurably much larger. One inference is that the rocks forming the bed of the Solent are more yielding than the rocks beneath the Irish Sea at Bidston. See Plate I.

A curious feature in the Ryde photograms is the flatness of many of the crests and hollows of the deflections, which seems to indicate that from time to time the water remains high or remains low for several hours.

On April 8 the instrument was turned through 90°, *i.e.*, the boom

[1] See *Brit. Assoc. Report*, 1910, p. 49.

was pointed north or towards the advancing and retreating tide; the resulting photograms are practically straight lines.

These observations were discontinued on May 24.

VII. *Tidal Load Experiments in Pennsylvania Railway Tunnels.*

Since 1909 a number of experiments have been made regarding the stability of the Pennsylvania Railway tunnels under the North or Hudson River. The results show that the tunnels rise and fall under the influence of the superincumbent tidal load. A 4.4-foot tide causes a variation in elevation of 0.008 feet.

This was arrived at by sinking a tube in certain instances to a depth of 200 feet through the silt beneath the bed of the tunnel until it reached the solid rock. A 2-inch iron rod passed freely down each of these tubes and was firmly fixed in the rock. The upper end of the rod passed through a stuffing-box on the top of the tube. The assumption made was that the top of this rod remained fixed and relatively to it the bottom of the tunnel rose and fell. This relative movement was recorded by a lever having a multiplication of ten which recorded on a strip of paper. The resulting diagrams have an exceedingly regular character and correspond in time with the records of a tide-gauge which gives the height of water in the river. The tunnels are resting in a quasi-fluid material and show slight depressions by the passing of locomotives. A load passing through the tunnel causes a wave-like action, a point immediately beneath the load being depressed, whilst the point 200 feet in advance of the same rises. I am indebted for this information to Mr. Forgie, Engineer to the North River Division.

VIII. *Experiments in Pits in the Midlands.* By J. J. Shaw.

The experiments commenced at the end of June 1910 by the installation of a horizontal pendulum in a chamber 1,960 feet below ground at the Sandwell Park Colliery, near West Bromwich. The instrument used was similar to the one used at Bidston, but with facilities for obtaining a somewhat higher degree of sensibility. The chamber was lined with several feet of concrete, but unfortunately the traffic of the pit passed within a few feet of it, whilst at a distance of about 100 feet there was a large sump from which water was pumped every night. From the outset it was seen that the strata were ever moving, the movements being partly due to pumping, blasting, and traffic. The direction in which the boom wandered was towards the dip of the strata. Observations were discontinued early in August, and the instrument was removed to a new colliery at Baggeridge, near Dudley, seven miles from its previous position. The instrument was installed at the end of a concrete-lined *cul de sac*, where only occasionally traffic passed, and then never nearer than 100 feet. The depth was 1,800 feet. Pumping took place once a month. The movements were very similar to those at West Bromwich, and there was a tendency for the boom to wander in the direction of the dip. In this instance this was towards the west, whereas at West Bromwich it had been towards the east. The outstanding feature of these experiments is that even at very considerable depths observers will not be immune from continual changes of level. In the early part of this year the rate of the film was changed

from 3 inches per day to 12 inches per hour, the object being to record earthquakes. A few small shocks have been recorded, but up to the present we have not succeeded in recording shocks of any magnitude. Great difficulty is experienced in working underground on account of the saline atmosphere, which causes corrosion. One device tried for keeping the connection between the style on the boom and the multiplying lever was a small pendulum where the bob was a globule of shellac and the suspension was a quartz fibre. This was found to work well and to be of great delicacy.

Our very best thanks are due to the Earl of Dartmouth for granting permission to work in the mine, and also to Councillors H. W. Hughes, F.G.S., and Ivor Morgan for rendering valuable assistance in carrying out these experiments.

IX. *List of Strong Shocks in the United States and Dependencies.* By Professor H. F. Reid.

The dates of the shocks between 1663 and 1737 are corrected so as to give them according to the present method of reckoning, which began in 1752.

Abbreviations.

B = Brighams' Catalogue, 'Memoirs of Boston Soc. of Nat. History,' vol. ii.; 'Note Additionelle,' by A. Lancaster.
H = Holden's Catalogue, 'Smithsonian Miscellaneous Collection,' 1887.
R = Rockwood's Lists in the 'American Journal of Science.'
P = Catalogues by Alexis Perrey. Also see Deckert's paper in the 'Gesellschaft für Erdkunde,' Berlin, 1902.
S = Stewart's Catalogue (manuscript).
M = Martin's List (manuscript).
McA = McAdie's Catalogue, 'Smithsonian Miscellaneous Collection,' part of vol. xlix.
I = An intensity sufficient to damage walls and chimneys.
II = ,, ,, to destroy a few buildings.
III = ,, which has resulted in widespread disaster (see British Association Report, 1908, p. 78).

Date	Place	Intensity	Remarks
1663 Feb. 5 .	New England States	I	Three violent shocks. (B., p. 3.)
1727 Nov. 8 10.40 P.M.	Newbury, Massachusetts	I	(B., p. 7.)
1732 Sept. 15 noon	Newbury, Massachusetts	II	Also felt at Boston. Strongest apparently in Montreal. (B., p. 8.)
1737 Dec. 17 11 P.M.	New York .	I	Severe enough to throw down chimneys. Felt in Boston and other places. (B., p. 9.)
1786 . .	Pavloff, Alaska	III	With volcanic eruption. (H., p. 31.)
1790 (?) . .	Inyo County, Cal.	III	Indians state that a shock similar to that of March 26, 1872, occurred about eighty years earlier. (H., p. 31.)
1806 March 24, midnight	Santa Barbara, California	I	Church walls cracked. (H., p. 32.)
1811–1813	New Madrid, Missouri	III	(References.—W. J. McGee, *Bull. G.S.A.*, 1892, iv., 411–414; G. C. Broadhead, 'The New Madrid Earthquake,' *Am. Geol.*, 1902, xxx., 76–87; W. J. McGee,

List of Strong Shocks—continued.

Date	Place	Intensity	Remarks
			'The New Madrid Earthquake,' *Am. Geol.*, xxx., 200–201; Edw. M. Sheppard, 'The New Madrid Earthquake,' *Jour. Geol.*, 1905, xiii., 45–62.)
1812 . .	Atka, Alaska .	III	(H., p. 32.)
1812 May .	Southern California	I	Continual shocks for 4½ months. (H., p. 32.)
1812 Oct. 8, 7 to 8 A.M.	Santa Barbara, Cal. San Juan Capistrano, Cal.	II–III	(H., pp. 32, 33.)
1812 Oct. 21 .	San Juan, Capistrano, Cal.	II	(H., p. 33.)
1812 Dec. 8 .	From San Diego to Purisima, Cal.	I	At San Gabriel, church badly cracked. (H., p. 33.)
1812 Dec. 21 .	San Fernando, Cal.	I	(H., p. 33.)
1813 or 1815 .	Santa Clara Valley (?), Cal.	II	(H., p. 33.)
1817 Oct. 5 .	Woburn, Massachusetts	I	(B., p. 17.)
1836 April 2 .	Pribyloff Islands, Alaska	III	(H., p. 34.)
1836 Aug. .	Pribyloff Islands, Alaska	III	(H., p. 36.)
1843 Feb. 8 .	West Indies .	III	Guadaloupe and Pointe Petre wholly destroyed. More than 5,000 people killed. Distinctly felt in various parts of the United States. (R., *A.J.S.*, xliv., p. 419.)
1847 . .	Alaskan Coast, Alaska	II prob	General earthquake, very severe at Sitka. (W. H. Dall, 'Alaska and its Resources,' p. 342.)
1849 Oct. 22 .	Commander Islands, Alaska	II–III	Violent earthquake lasting all night. (P.)
1849 . .	S.W. Guam .	II	(Reference: Peterm, *Mitt.*, 1905, li., p. 40.)
1852 Nov. 9 .	Fort Yuma, Arizona	I or II	The shocks continued almost daily for many months. (H., p. 38.)
1857 Jan. 8 and 9	Southern California	III	Due to displacement of the San Andreas fault in Southern California for a length of 225 miles. (See *Rep. Cal. Eq. Com.*, vol. i., pt. 2, pp. 449–451.) (H., pp. 48, 49.)
1865 Oct. 8, 12.45	San Francisco, California	II	Two violent shocks within half a minute. The accounts from Sacramento, Stockton, and San José represent the earthquake as the severest ever felt in those cities. Ten or eleven distinct shocks were felt after the first shaking up to 5 A.M. of the 9th. (See *Rep. Cal. Eq. Com.*, vol. i., pt. 2, pp. 448–449.) (H., pp. 65, 66, and R., xl., p. 366.)
1866 . .	Wamego, Kansas	I	(H., pp. 76–80.)

List of Strong Shocks—continued.

Date	Place	Intensity	Remarks
1868 Oct. 21, 7.50 A.M.	San Francisco and neighbourhood, California	III	Due to movement on the Haywards fault, east of San Francisco Bay. At the corner of Market and First Streets, San Francisco, the ground opened several inches wide for a distance of forty to fifty feet. The earthquake was severe in the interior. Felt at Sacremento and Stockton; at Redwood City, where the court-house was wrecked; Marysville, Grass Valley, and Sonora also felt the shock. (See *Rep. Cal. Eq. Com.*, vol. i., pt. 2, pp. 434-448.) (R., xlvi., p. 428.)
1869 Oct. 22, 6 A.M.	All over New England States	—	With an intensity of III. at Fredericktown, New Brunswick. (B., p. 22.)
1869 Dec. 27, 2.10 A.M.	Sacramento, California	II	(H., p. 84.)
	Marysville, Cal.	I	—
1872 March 26	Inyo County, California	III	Movement on fault. (See Holt's book.) (H., pp. 88-92.)
1872 Dec. 10, 4.30 P.M.	Helena and Deer Lodge, Mont.	I	Two shocks of five seconds' duration, direction West to East. (R., v., p. 262.)
1875 Dec., 8-9 P.M.	Porto Rico	I-II	Town of Arecibo nearly destroyed. (N.W. Porto Rico). (R., xii., p. 29.)
1877 Oct. 12, 1.53 P.M.	Portland, Oregon	I	Two shocks. (R., xv., p. 25; H., p. 100.)
1878 Aug. 29	Makuslin, Alaska	I	Town reported destroyed. (R., xvii., p. 16.)
1881 April 10, 2.05 to 2.10 A.M.	Santa Clara Valley and Valley of California	I	The centre seems to be in San Joaquin County; VII-VIII at Modesto; VI-VII at Stockton; VI at Merced; VI at Ione City; III-IV at Visalia. In the Santa Clara Valley, VI; at Hollister, VI; V at Salinas, Centerville, San Jose; IV at San Francisco. There may have been two centres of disturbance, one near Modesto and one near Hollister. Felt probably over an area of 15,000 square miles. (S.)
1882 Sept. 7 .	Panama, C.A. .	I-II	Shocks continued for three or four weeks. (S.)
1886 Aug. 31, E.S.T., 9.51.06 P.M.	Charlestown and Summerville, S.C.	III	See Ninth Annual Report U.S. Geol. Survey. (Dutton.)
1889 July 19 .	Memphis, Tenn.	I	—
1894 July 18, M.S.T., 3.50 P.M.	Ogden, Utah	I (?)	(H., p. 228.)
1896 May .	Orca, Alaska .	II (?)	Very severe. (M.)
1898 March 30, P.S.T. 11.42.15 P.M.	Mare Island, Cal.	I	(McA., pp. 11-12.)

List of Strong Shocks—continued.

Date	Place	Intensity	Remarks
1899 Sept. 3 to 10; Sept. 10 to 17	Yakutat Bay, Alaska	III	(References.—*Nat. Geog. Mag.*, x., 421; Tarr, 'Recent Changes in Alaska,' *Geog. Jour.*, 1906, pp. 30–43; L. Martin is publishing a *U.S.G.S. Bull.* on these earthquakes, 1910.) Felt from Lynn Canal to Aleutian Islands. Some islands said to have settled 20 to 25 feet. Strongest shock on September 10. The 'Bonanza' passed between Amukhta and Yumaska Islands (Aleutian Islands) on September 17; both islands are volcanic cones and great clouds of smoke were issuing from both.
1899 Dec. 25, 4.29 A.M.	Santa Jacinto, Riverside Co., S. California	I	Shocks continued. Thirty on 25th day, others on the 26th day. Felt from San Diego, California, to Seligman, Arizona.
1900 Oct. 9	Prince William Sound, Alaska	III	Felt over an area of 121,000 square miles on land. (M.)
1901 Dec. 30–31	Kenai, on Cook Inlet, Alaska	III (?)	A strong volcanic eruption. Earthquake which accompanied it caused several tidal waves.
1902 July 27, 11 P.M., to 31	Los Alamos, Cal., and neighbourhood . .	I	—
1902 Sept. 22	Guam . .	II–III	(*Peterm., Mitt.*, 1905, li., p. 40). 180 shocks experienced in 24 hours.
1902 Nov. 17, M.S.T. 12.53 P.M.	Washington Co. S.W. Utah	I	—
1905 Dec. 23, P.S.T., 2.23 P.M.	Bakersfield, California	I or less.	Three shocks.
1906 Jan. 25, M.S.T., 1.32.30 P.M.	Flagstaff, Arizona	I	Duration 20 sec. Probably in San Francisco mountains, north of Flagstaff.
6.36.7 P.M. 7.31 P.M.	. . . . .	. .	After-shocks.
1906 April 18, P.S.T., 5.11.58 A.M.	Along coast of California	III	Disastrous shock which destroyed San Francisco and did serious damage in many other cities. The earthquake was caused by a movement on the San Andreas fault for a length of 270 miles. Many after-shocks. (See *Rep. Cal. Eq. Com.*)
1906 April 18, P.S.T., 4.26 P.M.	Brawley, S.E. California	I	Duration 10 sec. Probably felt over an area of 30,000 square miles.
1906 July 12, M.S.T., 5.15 A.M.	Socorro, New Mexico	I	Many shocks between July 2, 1906, and end of year. Probably felt over 60,000 square miles.
1906 July 16, M.S.T., 12 noon	Socorro, New Mexico.	I	Probably felt over 60,000 square miles.

List of Strong Shocks—continued.

Date	Place	Intensity	Remarks
1906 Sept. 27, 10.47 A.M. (14.41.30 G.M.T.)	San Juan, Porto Rico, Santo Domingo, and St. Thomas	I	Duration 30 sec. Shock general throughout Porto Rico. Felt for a distance of 300 to 350 miles. Probably central near San Juan. (P.R.)
1906 Nov. 15, M.S.T., 5.15 A.M.	Socorro, New Mexico	I	This was the severest of a long series of shocks which began on July 2 and lasted seven or more months. Probably felt over an area of 100,000 square miles.
1908 Feb. 14	Prince William Sound, Alaska	II (?)	Cables broken in Valdez Fiord. Recorded at distant seismograph stations (M.)
1908 May 14, 11 P.M. ± (8.32.30, ± May 15, G.M.T.)	Near Yakataga, Alaska	II (?)	—
1908 Aug. 18, 2.59 A.M. 3.08 A.M. 5.27 A.M.	Eureka, California	I	Area of the shock probably not more than 200 or 300 square miles. First shock did all the damage.
1909 Oct. 28, P.S.T., 10.48 P.M.	N.W. California and S.W. Oregon	I	Duration 22 sec. The centre of the shock was near Fortuna, Humboldt Co., Cal. (near Eureka), where chimneys were thrown down and much plate-glass broken. At Ferndale and Eureka the shock was nearly as strong. Probably felt over an area of 250,000 to 300,000 square miles on land. Probably due to a slip on a fault near Fortuna.
1909 Oct. to Dec.	North of Great Salt Lake, Utah	I	Thirty or sixty shocks reported from the old lake deposits just north of the present Great Salt Lake.
1909 Dec. 10, Local time, 9.10 A.M.	Agano, Guam .	II	Two shocks, duration 22 sec. This was a heavy shock and did very serious damage to buildings in Agano. Small fissures were made in the ground and water spouted out in places. These were near high-water mark and were undoubtedly due to slumping and vibrations. Surface waves were also seen. Recorded at Manila at 23.33.9 and at Honolulu at 23.29.7 G.M.T. This would put the time at the origin, supposed close to Agano, about 23.30 G.M.T.

X. *List of Destructive Earthquakes which have occurred in Peru and North Chile.* By H. HOPE-JONES, Esq., *Lima.*

All entries in this list are, with the exception of eight, additional to those found in the provisional list by Count Montessus de Ballore

(see British Association Report, 1910, pp. 69-71). Where dates have differed in these two lists those given by the latter author are placed in brackets. The meaning of intensities given by the numerals I, II, and III are explained on p. 47.

Date	Classification	Approximate Epicentre
1578 June 17	II	Lima
1582 January 22 (January 16)	III	Arequipa
1582 July 2	III	,,
1586 July 9	III	Lima
1590 ?	III	Camaná
1604 November 23 (November 24)	III	Arequipa
1609 October 19	II	Lima
1619 February 16	III	Trujillo
1630 November 27	II	Lima
1647 May 13	III	C. Chile (?)
1650 March 31	III	Cuzco
1650 March 31	III	Lima
1655 November 13	III	,,
1658 February 14	III	Trujillo
1664 May 12	II	Ica
1687 October 20	III	Lima
1699 July 14	I	,,
1716 February 6	I	Torata
1725 January 6 (January 8)	III	Ancash
1725 March 27	III	Camaná
1746 October 28	III	Lima
1747 ?	I	Carabaya
1777 January 26	I	Lima
1784 May 13	III	Arequipa
1794 March 26	I	Lima
1806 December 1	I	,,
1813 March 30	II	Ica
1814 February 1	I	Piura
1821 July 10	III	Arequipa
1828 March 30	II	Lima
1831 October 8	II	Arequipa
1833 September 18 (October 18)	II	C. Tacna
1839 June 10	I	Ica
1857 August 20	I	Piura
1860 April 18	I	Arequipa
1860 April 22	I	Lima
1861 April 13	I	Andahuailas
1868 August 13	III	Arica
1869 August 24	II	Pica
1869 November 3	I	Arequipa
1871 February 22	I	Puno
1871 August 2	I	Arequipa
1871 October 5	I	C. Iquique
1872 January 10	I	Arequipa
1873 June 10	I	,,
1875 April 5	I	Trujillo
1875 December 5	I	Abancay
1877 May 9	III	C. Arica
1878 January 25 (January 23)	I	C. Iquique
1883 October 1	I	Arequipa
1897 September 20 (September 23)	I	Matucana
1898 June 20	I	Ica

XI. *Unpublished Notes relating to Destructive Earthquakes.*

On February 25, 1897, on behalf of the Seismological Committee, I approached the Under-Secretaries of State for Foreign and Colonial Affairs with the object of obtaining their assistance in the compilation of a list of destructive earthquakes. On April 10 a similar application was made to the India Office. These applications received favourable consideration, and a letter, of which the following is a copy, was forwarded to his Majesty's Representatives in certain Foreign Countries, English Colonies, and Dependencies:—

SIR,—At the present time there exists no complete list of the destructive earthquakes which have occurred in various parts of the world, but portions of such a list are now being compiled by the Seismological Committee of the British Association for the Advancement of Science, but the information is defective as to many countries. It is desired, therefore, to obtain such a register giving the dates and places of origin of earthquakes which have produced structural damage in the country in which you have the honour of representing his Majesty's Government. In the list of earthquakes which it is hoped you may be the means of obtaining, the numerals I, II, and III should be attached to each entry. No. I should refer to those shocks which have shattered a few structures. No. II should be attached to those which have destroyed structures in a limited area. No. III to those which have caused destruction over a large area.

As the records of small earthquakes are not required, the list we ask for will in most instances be short. In some countries such a list may already exist in print.

The objects in view are threefold. First, to provide material for scientific analysis; second, to determine the frequency of destructive disturbances in various countries; and third, to map out areas where special precautions should be taken with regard to construction.

I trust you will find it possible to co-operate in the collection of this material, which will possess not only scientific but also practical utility.—I remain, Sir, on behalf of the Committee, your obedient servant,

JOHN MILNE,
Hon. Secretary Seismological Committee of the British Association.

The following notes are a *résumé* of the replies which have been received to this letter. In many instances printed matter, as for example the Proceedings of learned societies, special works, official documents, were sent to Shide. As these are in nearly all cases accessible to those who desire to see them, I only refer to them by name. So far as possible the earthquakes referred to are those not included in the 'General Catalogue of Destructive Earthquakes.' The countries are arranged alphabetically.

Abyssinia.—Lord Herbert Hervey, Hon. Chargé d'Affaires, reports that no records have been kept so far as he has been able to ascertain. Earthquakes which have taken place in recent times have ben insignificant, and not of sufficient force to bring them within categories I, II, or III.

West Australia.—The Governor, H.E. Sir Gerald Strickland, reports that no destructive earthquake has been experienced in Western Australia.

South Australia.—The Government Astronomer, G. F. Dodwell, reports on two earthquakes, May 10, 1897, Class II, origin submarine and not far from Kingston and Beachport. At Kingston, Robe, and Beachport walls and chimneys were thrown down; slight damage

extended within a radius of about 250 miles from the origin. September 19, 1902, Class I, origin near Kangaroo Island. Some houses at Warooka were wrecked, walls were cracked within a radius of one to two hundred miles. Both earthquakes were considered due to fault lines running north and south from Lake Torrens through Spencers and St. Vincent Gulfs. A pamphlet on South Australian earthquakes is in course of publication.

Queensland.—The Hon. Sir Arthur Morgan, Lieut.-Governor, reports that no records have been kept; and for the last thirty-two years at least Mr. J. B. Henderson says that Queensland has been singularly free from such disturbances.

Victoria.—Sir T. D. Gibson Carmichael writes that the Government Astronomer is collecting information, which, when completed, will be sent to Professor John Milne at Shide.

New South Wales.—The Hon. G. B. Simpson reports that, so far as State records show, no earthquake of sufficient severity to cause damage has been experienced in New South Wales.

Tasmania.—H.E. Major-General Sir Harry Barron writes that he is informed by the Premier that no destructive earthquakes have occurred in Tasmania within the memory of man.

Canada.—The Secretary of State for External Affairs, the Hon. Charles Murphy, says that the earthquake of 1663, which was felt throughout the St. Lawrence Valley, was destructive. The earthquake of October 1870 did slight damage to chimneys and ceilings, especially at Baie St. Paul, on the north shore of St. Lawrence below Quebec.

Cape of Good Hope.—The Rt. Hon. Sir W. F. F. Hely-Hutchinson forwards two minutes from Ministers, but no earthquakes are reported.

Ceylon.—Sir H. E. McCallum says that so far as can be ascertained there are no records of destructive earthquakes in Ceylon. Slight shocks have stopped clocks and produced cracks in one or two houses.

Cyprus.—Sir C. A. King-Harman states that although slight shocks of earthquakes have occasionally been experienced, nothing of a destructive nature has occurred since the British occupation.

Chile.—H.E. H. C. Lowther writes that the Director of the Seismological Department is compiling a catalogue of earthquakes in Chile. A provisional list of destructive earthquakes which have occurred in the Southern Andes south of latitude 16, by Count de Montessus de Ballore, will be found in British Association Report, 1910.

China.—Sir John N. Jordan sends 'Catalogue des Tremblements de Terre Signalés en Chine d'après les Sources Chinoises, 1767 B.C. to 1895 A.D.,' par Le R. P. Pierre Hoang. A translation of extracts from the 'Shun T'ien Fu Gazeteer,' which gives a list of earthquakes from 1665 to 1883; a list of earthquakes in 1882. This is attached to a paper by Dr. Macgowan, see 'China Review,' vol. 14, pp. 147-150. All this information will be incorporated in a catalogue of destructive earthquakes published by the British Association. *This is now in the press.*

Colombia.—H.E. the British Minister, Francis W. Stronge, very kindly forwarded a list, obtained from the Columbian Minister for Foreign Affairs, of severe earthquakes felt in that Republic between 1625

and 1910. With the exception of the two following these have been incorporated in the 'Catalogue of Destructive Earthquakes': 1906, January 31, 10 A.M., the following towns were destroyed: Bocagrande, Cape Manglares, Puerto Limones, Salahonda, Las Baras, Trujillo, and Chagal. 1910, March 30 and 31 and April 1, great landslides at Sutamarchin in Boyaca.

Costa Rica.—Consul F. N. Cox sent a detailed account of the earthquake of April 12-13, 1910. Shocks commenced April 13, 12.37 A.M. or 6.13 G.M.T. The greatest damage was done at 1.5 A.M. or 6.41 G.M.T., and at 8.30 A.M. or 14.6 G.M.T., on April 14. The hypo-centre was south-west of Cartago, which, with San José and many villages, suffered great damage. On May 4, 6.50 P.M., or May 5, 0.26 G.M.T., Cartago, Paraiso, and surrounding hamlets again suffered. The shock was felt in all parts of the Republic and also in Bocas del Toro.

Denmark.—The First Secretary of the British Legation, Mr. J. C. T. Vaughan, forwarded an account of two earthquakes which occurred in 1837 and 1867 in the island of St. Thomas (see St. Thomas).

Egypt.—Councillor R. W. Graham sends notes on the following three earthquakes: 1847, a minaret was thrown down in Cairo; 1887, Suakin on the Nile Valley was disturbed, houses in Cairo damaged; 1906, December 26, the Nile Valley and the Red Sea coast were shaken, the lighthouses of Shadwan and Ashrafi in the Red Sea were damaged; origin probably about 26° N. lat. The intensity of these shocks was of the order No. I.

Fiji.—The Hon. Charles Major reports that no seismological records have been kept in Fiji, and beyond ordinary slight shocks no serious earthquakes have been known to occur in the Colony.

France.—The Hon. L. D. Carnegie sends a note for Monsieur Pichon which refers to three earthquakes felt in 1889. The first of these occurred on June 11, in the Departement des Bouches du Rhône; destruction occurred within an area of 360 kilometres square. The second occurred on June 23, in the Departement Vendée; no damage. The last took place on August 5, in Bretagne, and was felt throughout Finistère; the damage was small.

Gambia.—The Governor reports that no earthquakes have been recorded.

Gilbert and Ellice Islands.—The Resident Commissioner writes that earthquakes appear to be unknown in that Protectorate.

Gold Coast.—H.E. Sir J. P. Rodger sends a Report of a destructive earthquake which occurred at Accra in 1862; Christiansborg Castle was laid in ruins. This was on July 10. In Jamestown all the stone houses were entirely overthrown.

Greece.—Sir F. E. Hugh Elliot transmits a list prepared from the records at the Observatory at Athens of destructive earthquakes in Greece from 1893 to November 1909. Those which are not in the 'Catalogue of Destructive Earthquakes' are as follow: 1909, June 15, 23.26 G.M.T., at Lamia and Domoko, some walls were cracked. 1903, August 11, 4.37 G.M.T., at Cythera, the village of Mytata was destroyed; opposite Biaradika the ground was cracked for 200 metres; at Cythera and Potamos houses were rendered uninhabitable.

1909, May 30, at Vitrinitsa (Doris), at 6.15, the village of Douvia was destroyed, houses damaged at Vitrinitsa and Palaioscarion, Galaxidi and Itea. 1905, January 20, at Aghuia, at 2.32, destroyed houses in the villages of Aramidi, Sklethron, and Canalia. 1909, July 15, at Amalias (Elis), at 0.35, the villages of Amalias, Havari, Sinoti, Lopesi, Bouchioti, Calyria, &c., were overthrown.

Guatemala.—H.E. British Minister, L. E. G. Carden, forwards a list of earthquakes in Guatemala City. Those not in the 'Catalogue' are: 1902, April 19, 2 A.M., great destruction in Quezaltenango, also in Guatemala City. 1907, September 24, 10 A.M., damaged building in Guatemala City.

British Guiana.—H.E. Sir F. M. Hodgson reports that no destructive earthquakes have taken place in Demerara, but slight earth tremors have been felt from time to time.

Honduras.—Through H.E. L. E. G. Carden, Esq., brief notes are sent relating to violent shocks on January 20-23, 1835, and slight shocks which did some damage to buildings in 1897, 1899, and 1902. They occurred in the north-west and centre of Honduras, and coincided with similar movements in Guatemala and Salvador. The Republic of Honduras, as a whole, is free from earthquakes.

Iceland.—Sir Allan Johnstone sends with a translation a copy of Thoroddsen's 'Icelandic Earthquakes' ('Landskjalfar A Islandieftir,' Thorvald Thoroddsen, Copenhagen, 1899 and 1905).

India.—Through the India Office we received lists of destructive earthquakes published by the Asiatic Society of Bengal and the Geological Survey of India.

Kashgar.—His Majesty's Consul, Mr. George Macartney, in Kashgar sends extracts from his diaries relating to the following disturbances: 1902, August 22, 8 A.M. (2.56 G.M.T.), buildings much damaged, the village of Artush destroyed, there were many after-shocks; the most severe of these occurred on August 24, 26, and 30, September 1 and 2, about 10 P.M. or 4.56 G.M.T.

Loanda.—Mr. Consul H. C. Mackie says that on February 27, at 2 P.M. (local time), there was an appreciable earthquake shock at Benguella.

Malta.—H.E. Gen. Sir H. M. L. Rundle forwards a list of seven destructive earthquakes which have been noted in Malta. These are all included in the 'General Catalogue.'

Malay States.—The High Commissioner of the Malay States reports that there are no records of destructive earthquakes.

Mauritius.—Mr. J. Middleton, Assistant Colonial Secretary, states that there is no record of any destructive earthquake ever having occurred at Mauritius.

Mexico.—H.E. Reginald T. Tower, C.V.O., sends a voluminous report in Spanish which was drawn up by the Geological Institute; with the exception of the following all the entries relating to destructive earthquakes will be found in the 'General Catalogue': 1900, January 19, 11.45 P.M. local time, strong in Colima, buildings suffered much, particularly the cathedral; damage was also done in Ejulta, Jalisco, Michoacan, Guerrero, and other places. 1902, January 16, 5.19 P.M.

local, Chilpancingo, Chilapa, and Tixtla, and over all the south of the Republic and in Guatemala. 1905, May 9, 0.8 A.M. local, severe in Autlan, in Jalisco, and felt throughout the Central States. 1907, April, 14, many houses destroyed in Guerrero; it was felt in Mexico City at 11.31, 10 P.M. local, the epicentre was at San Marcos. 1908, March 26, much destruction at Ometepec in the State of Guerrero, felt all over the south of the Republic; it was recorded in Mexico City at 9.12 P.M. (March 27, 3.48.5 G.M.T.). 1909, July 30, Mexico time 4.15.57 A.M. (10.52.27 G.M.T.), epicentre near Acapulco, where many houses were destroyed and the sea retreated from the coast. Destruction also occurred at San Marcos and Chilpancingo; extending over an area 435 by 310 miles.

Montenegro.—Mr. W. O'Reilly states that there is no record or recollection of a destructive earthquake in the Principality.

Morocco.—Mr. W. F. Rattigan writes that within the memory of the oldest inhabitant nothing beyond shocks of the very slightest nature have been felt, and so far as it is possible to ascertain no violent earthquake has occurred in Morocco in historic times.

Natal.—The Hon. Sir Henry Bale reports that earthquakes are very exceptional in Natal and in every recorded case have been very slight.

Nigeria.—The Acting Colonial Secretary states that in this colony and protectorate so far as is known earthquakes have not occurred.

New Guinea, Papua.—Through the Rt. Hon. the Earl of Dudley and the Acting Prime Minister of the Commonwealth of Australia we learn that so far as can be ascertained there is no record of any destructive earthquake in Papua except the one at Buna Bay on October 2, 1906. This took place at 11.35 A.M. (local time); the shaking lasted three minutes and was accompanied by heavy sea waves. Slight tremors are felt throughout the territory six or seven times per year.

Nyasaland.—Sir Alfred Sharpe states that no destructive earthquakes have occurred since the Protectorate has been known to Europeans. Mild shocks are felt from time to time on the north and west shores of Lake Nyasa. To the north of this lake there is a volcanic district, with crater lakes and many hot springs. Earthquakes occurred at Zomba on June 6 and 7, 1910. The one on June 6 took place at 22.23 and was pronounced, but there was no damage.

New Hebrides.—The Resident Commissioner reports that earth tremors are frequent, but no shocks have been felt since his arrival in November 1907.

New Zealand.—H.E. Rt. Hon. Lord Plunket forwards a list of destructive earthquakes by Mr. G. Hogben. These will be found in the 'Transactions of the New Zealand Institute,' vols. 37 and 38. The one on August 9, 1904, originated at 22.49 G.M.T., 179° E. long., 42° S. lat. Others of importance which are not included in the 'Catalogue' occurred on November 16, 1901, and on July 29, August 9, and September 8, 1904.

Norway.—A short list, prepared by Dr. Carl Fred. Kolderup, has been forwarded to us by Mr. T. J. Wingfield. One on October 23, 1904, destroyed many chimneys in the Prefectures of Smaalenene, Jarlsberg and Larvik, also in Bratsberg and Buskerud.

Palestine.—Consul E. C. Blech has forwarded a list of earthquake shocks felt at Jerusalem since 1864. These were extracted from records kept at the Hospital of the London Jews Society in Jerusalem. One which took place at 2 A.M. local time, January 5, 1900, and another which occurred on March 31, 1903, at 12.45 A.M. local time, are not included in our 'Catalogue'; the latter damaged buildings in Jerusalem.

Panama.—The Minister Resident, Claude C. Mallet, sends a short list of earthquakes which have caused damage in this Republic. Slight shocks occurred on July 7, August 17, 1908, May 3, July 28, August 28 and 30, 1909, but these were not of a serious nature.

Paraguay.—Mr. G. W. E. Griffith states that no records exist to show that any destruction to property has ever been caused by earthquakes in this Republic.

Persia.—H.E. Sir G. Barclay sends a report of two earthquakes which occurred in the Kerman district: April 18, 1911, 9.52 P.M. or 5.22 G.M.T., a shock damaged a few buildings in Kerman; March 28, 1911, also at 5.22 P.M. G.M.T., but it did not cause damage.

Peru.—Consul-General Lucien J. Jerome forwards a list of earthquakes compiled by Mr. Hope Jones, a member of the Geographical Society of Lima. See this Report.

Rumania.—Sir W. Conyngham Greene forwards a pamphlet published by the Astronomical and Meteorological Society of Bucharest on 'Mouvements Sismiques en Roumanie pendant la periode 1907-1909.' Mr. R. J. Hamilton forwards a number of pamphlets from the 'Annales de l'Institute Meteorologique' containing lists of earthquakes for the years 1891-1908.

Salvador.—The British Minister, L. E. G. Carden, sends a list of earthquakes compiled by the Director of the National Observatory of San Salvador. The following are not included in our 'General Catalogue': July 19, 1906, had an intensity corresponding to No. VII on the Rossi-Forel scale. In May and June 1909 slight shocks were felt, and again in October 1910.

Servia.—The British Minister, Sir James B. Whitehead, forwards a list of destructive earthquakes prepared by the Geological Institute of the University in Belgrade, covering the period 1755-1905 inclusive. The following are not included in our 'Catalogue': January 30, 1902, at Mostanica, Ristovac, Vranje, and Vranjska Banja; these places were also shaken on April 4 and 10, 1904. On January 6, 1905, and July 24, 1906, places lying between 44° 22′ and 44° 32′ N. lat. and 19° 21′ and 19° 29′ E. long. were severely shaken. On May 13, 1905, the district 43° 41′ to 43° 44′ N. lat. and 21° 46′ to 21° 54′ E. long. suffered.

Siam.—Consul W. R. D. Beckett transmits a copy of a note which he has received from his Royal Highness Prince Devawongse to the effect that seismic disturbances in Siam have been very few in number, and in no instance have they been violent enough to destroy or damage buildings.

Sierra Leone.—The Acting Colonial Secretary writes that there is no record of any destructive earthquake in the history of the colony.

In another note Lieut. H. C. Lukach refers to a slight earthquake which occurred at Freetown on July 28, 1897, at 11 A.M.

Solomon Islands.—The High Commissioner for the Western Pacific understands that earthquakes are of frequent occurrence in the western part of the group. They are all of a slight nature.

St. Helena.—H.E. Lieut.-Colonel Sir H. L. Gallwey writes that there is no record of a destructive earthquake ever having taken place in St. Helena since the island was discovered. The only records of earthquakes refer to the years 1756, 1780, 1817, and 1864, but no damage occurred.

Straits Settlements.—The Colonial Secretary writes that no destructive earthquakes have occurred in the Straits Settlements during the last twenty years.

Spain.—H.E. Rt. Hon. Sir M. W. de Bunsen says that a list of Spanish earthquakes is being collated and will be forwarded in due course.

Tonga, or Friendly Islands.—The Agent and Consul for Tonga states that no records have been kept of earthquakes, and that no destructive earthquakes have been experienced within the group except at the volcanic island of Niafoou.

Tripoli.—The Acting Consul-General, Alfred Dickson, states that, with the exception of feeble shocks at wide intervals, Tripoli has not been visited by any earthquake which can be classed under the Nos. I, II, or III of the circular of the British Association.

Tunis.—Consul-General E. J. L. Berkeley reports that after full inquiry he cannot hear of any records of earthquakes in this region. There has, however, been once or twice extremely slight seismic disturbances.

Uganda.—Mr. W. A. Russell says there are no records of any earthquakes such as are mentioned in the British Association circular.

Uruguay.—Mr. Ernest Scott states that he is informed by the Director of the National Physical and Climatological Observatory at Montevideo that the Republic of Uruguay is not disturbed by local earthquakes, although shocks of some severity have occasionally been felt, presumably caused by vibrations in the Andes Range or other distant localities. Professor Luis Morandi has kindly undertaken to prepare a memorandum which he thinks may interest the Seismological Committee of the British Association.

Venezuela.—Sir Vincent Corbett forwards a list of the principal earthquakes which have occurred in Venezuela since the middle of the nineteenth century. This was compiled by the Director of the Observatory in Caracas. It only contains one reference which is not in our ' General Catalogue.' This occurred on October 29, 1900. The districts affected were situated from 40 to 100 kilometres east of Caracas, which suffered but slightly. Destruction also occurred in Guarenas, Guatire, Rio Chico, Higuerote, and in Macuto.

West Indies: Antigua.—Mr. H. A. Tempany reports on destructive earthquakes in April 1690 and 1833; February 8, 1843. Since 1889 records of earthquakes have been kept. May 29, 1895, shocks were felt in Antigua, St. Kitts, Montserrat, and Barbuda, where

slight damage occurred. April 29, 1897, shocks felt at Antigua, St. Kitts, Dominica, and Guadeloupe, where considerable damage was done to buildings. December to January 1897-98 and September and October 1900, shocks of some intensity occurred in Montserrat and slight shocks were frequent in Antigua. December 3, 1906, in Antigua, and as far south as Barbados, slight damage occurred to buildings in most islands.

Bahamas.—Commissioner P. W. B. Armbrister says that no destructive earthquakes have occurred at Inagua since 1896. In September 1887, however, in two or three weeks shocks were felt nearly every day. They were preceded by rumblings which came from the south. Boundary walls and a few old buildings were thrown down; a considerable number of stone buildings were slightly cracked. It was at this time that the city of Port de Paix, Haiti, was partly destroyed. The Inspector of Lighthouses, Mr. F. J. Lobb, reports that earthquakes were experienced on September 23, 24, 25, and 26, 1887, at the following lighthouses: Inagua, Castle Island, Bird Rock, and Watling Island. One on September 23 at 7 A.M. and 8.10 P.M. local time was the most severe, and caused trifling damage.

Barbados.—H.E. the Governor reports that there are no records of destructive earthquakes.

Bermuda.—The Governor, Lieut.-Gen. Walter Kitchener, reports that no earthquake has occurred in Bermuda coming under the heading of the Circular of the Seismological Committee since the settlement of the colony in 1612.

Dominica.—The Hon. W. H. Porter says that during his forty years' experience of the island he only recollects one earthquake of any force. This occurred between four and six years ago. It exerted its greatest force in the northern half of the island, where a masonry chimney was wrenched. At the other extremity of the island the walls of a village church were slightly damaged. Shocks are felt with greater frequency in the northern and eastern district than to the south and west of the central mountain chain.

Grenada.—The Colonial Secretary, E. R. Drayton, sends an extract from the history section of the Grenada handbook referring to severe earthquakes in 1766, November 18, 1867, and January 10, 1888.

Hayti.—Consul-General Alex. P. Murray sends a short description of destructive earthquakes which occurred in 1564, 1770, May 7, 1842, September 23, 1887. The frequent slight earthquake shocks at Port-au-Prince are generally preceded by a subterranean noise which approaches from the plains and passes beneath the town. No movement of the earth is perceptible. The Haytians call it 'le gouffre,' or 'le bruit de gouffre.'

Montserrat.—Lieut.-Colonel W. B. Davidson-Houston states that, with the exception of the earthquake of February 8, 1843, there do not appear to have been any earthquakes of a serious nature within recent years. In 1896-7-8-9, and again in 1901-2-3, there were numerous slight shocks, but none of these did more than very slight damage, although their frequency made them very alarming. A copy of President Baynes' speech to the Montserrat Legislature on the subject of the earthquake of 1843 was enclosed.

St. Christopher (St. Kitts and Nevis).—The administrator, Mr. T. Lawrence Roxburgh, only reports on one destructive earthquake, viz., that which took place on February 8, 1843.

St. Croix.—The First Secretary of the Legation in Copenhagen, Mr. C. T. Vaughan, states on the authority of M. Erik Scavenius that when the island of St. Thomas suffered on November 18, 1867, the neighbouring island, St. Croix, was left almost intact.

St. Lucia.—The Administrator refers to the earthquakes of January 11, 1839, which damaged buildings in Castries; that of February 8, 1843; and, lastly, that of February 16, 1906, which also did considerable damage in Castries.

St. Thomas.—This island was badly shaken on August 2, 1837, and again on November 18, 1867 (see St. Croix).

St. Vincent.—The Agricultural Superintendent does not think that St. Vincent has experienced any destructive earthquake since historic times, and from an inspection of old forts and buildings he considers this statement corroborated. Of course, there are many slight shocks.

Tortola.—Commissioner Leslie Jarvis, after a careful and long search among records of this Presidency, states that the only reference to an earthquake which he has come across is that of November 18, 1867. Reports on this earthquake will be found in Sir A. Rumbold's despatch No. 83 of November 25, 1867, and in the diary of Mr. G. H. A. Porter, Administrator in the Virgin Islands, an extract from which is contained in despatch No. 96, December 23, 1867. This earthquake also created great damage in St. Thomas, St. John's, and St. Croix. It was accompanied by sea waves. Copies of these despatches were enclosed.

Trinidad.—Notes compiled by Mr. R. J. L. Guppy, M.A., late Inspector of Schools, refer to shocks on September 20, 1825, July 10, 1863, and January 10, 1888. All of these created considerable damage. Other shocks were noted on September 26, 1866, at 5.37 P.M.; July 7, 1868, 5.1 A.M.; November 17, 1885, 6.55 A.M.; May 7, 1886, 1.45 A.M.; May 17, 1886, 3.53 A.M.; May 5, 1887, 3.39 P.M.; January 10, 1888, 8.55 A.M.; October 5, 1890, 2.31 A.M.; November 20, 1890, 4.30 A.M. The time for these minor shocks is local.

Virgin Islands.—See St. Thomas, St. John's, and Tortola.

Cuba.—The British Minister and Consul-General, Mr. Stephen Leech, forwards a list of earthquakes, compiled by Mr. Consul Mason, recorded at Santiago de Cuba.

XII. *Seismic Activity* 1899-1903 *inclusive.*

The earthquakes referred to in the following list are those which have been recorded at stations all over the world, or at stations representing an area not less than that of Europe and Asia. Movements which have only been noted in a single continent have not been considered.

Although this catalogue may be used as a basis for many investigations, its main object is to show at a glance the regions in which important reliefs of strain have, in and beneath the crust of the world, taken place in recent years. The numbers given to the earthquakes

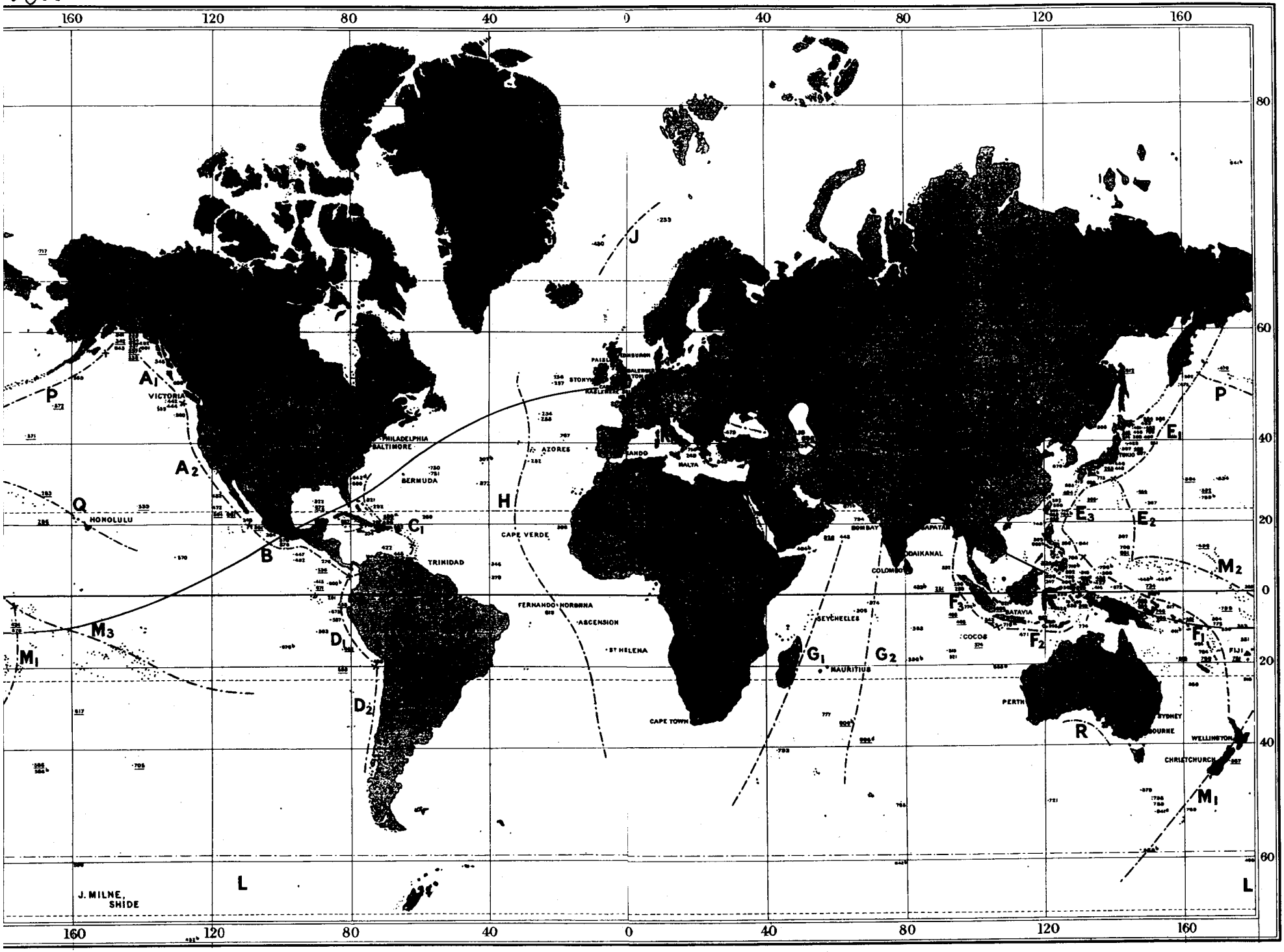
correspond to those of records obtained at Shide and published in British Association circulars. The small numbers which appear on the map (Plate II.) by their positions approximately indicate those of origins. The greater number of these, it will be observed, have been submarine. To make these determinations for each earthquake a list of the principal stations at which it had been recorded had to be drawn up. This showed the times at which P_1, P_2, P_3, and the maximum had been noted, together with the amplitudes recorded at each station. In the publications of the International Seismological Association, the Earthquake Investigation Committee of Japan, and in papers on particular earthquakes this fundamental data has for similar work always been published, but here it has been omitted. The reason for this is that it would occupy some three hundred pages, together with the fact that it can at any time be reproduced by consulting British Association and other Registers.

The names of places where an earthquake has been felt are followed by the letter 'F,' whilst those at which destruction has taken place are indicated by the letter 'D.' In these instances local observations in or near to an epifocal region have been used to determine the approximate position of a district from which an earthquake radiated and the time of its origin.

In cases where we have been without this local information, origins have been determined by selecting five or six stations at which the earthquake arrived first and where their amplitudes were large, and with this data we have computed the position sought, by methods well-known to seismologists. The method I find most satisfactory is that of circles (see British Association Report, 1900, p. 79). This has been applied to the differences in time at which P_1, P_2, P_3 or the maximum were recorded at *selected* stations. Another method which gives the distance of an origin from a station is the difference of time between the arrival of any two of these phases of motion. The results as to the times of occurrence at and position of an origin have been checked by comparing the computed times at which the earthquake should be noted at stations not included in the group of *selected* stations with the times actually recorded at the *non-selected* stations. In consequence of this method of working I have been led to the idea that certain seismograms which have hitherto been referred to as a single disturbance may refer to two or more disturbances (see p. 32). When an indicated time is followed by *plus* or *minus* two or more minutes, this also means that there is a corresponding uncertainty as to the position of an origin. All other times given may be read to within *plus* or *minus* one minute, unless they refer to records made in inhabited districts. These latter are probably correct to within 30 seconds.

The dotted lines on the map which are parallel to mountain ranges or oceanic ridges and troughs are the axes of districts from which many large earthquakes have originated. They are indicated by the letters A, B, C, &c. In the list two of these capital letters indicate that the earthquake originated near to the junction of two ridges.

The materials chiefly used for these investigations have been those obtained from stations co-operating with the British Association using



Earthquake Districts are indicated A, B, C, &c. Small numbers refer to Shide Records (see British Association Circulars). If underlined were recorded all over the World.

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similar instruments. Most valuable assistance has however been received from the publications of the Earthquake Investigation Committee of Japan, the International Seismological Association, the Commission Sismique Permanente of the Imperial Academy of Sciences of St. Petersburg, the Société Sismologica Italiana, the K. Natuurkundige Vereeniging in Nederl-Indie, the Bulletins of the Manila Central Observatory, and the weekly, monthly, and other circulars issued by observers in various parts of the world.

The chief difference between the present map and the four corresponding maps already issued by the British Association is that it contains more entries and shows more clearly the present-day sites of seismic activity. The small numbers on the map which are underlined refer to earthquakes which have been recorded all over the world, whilst the remainder indicate earthquakes which were recorded over areas which are approximately those of half our sphere.

Dual or multiple earthquakes are linked by brackets, and the stations used for the determination of their origin are named.

Compilations referring to the next five years have been completed, but it was felt they could not be entered on the present map for want of space, and are therefore held over for the next Report.

The number of megaseisms which have taken place in the different regions in the period considered are as follows: A_1 twenty, A_2 eight, B fourteen, C_1 thirteen, C_2 five, D_1 six, D_2 seven, E_1 eighteen, E_2 seven, E_3 twenty-three, $E_{1,2,3}$ one, F_1 thirty-three, F_2 ten, F_3 twelve, G_1 five, G_2 seven, H fourteen, J two, K_1 ten, K_2 five, K_3 ten, K_4 four, K_5 three, K_6 three, K_7 two, K_8 nil, L four, M, twelve, M_2 eleven, M_3 two, O five, P five, Q five, R nil, B D_1 two, K_5G_1 four, F_1M_1 two, G_1G_2 one, P E_1 one, A_2B two, $K_{1,2,3}$ five, F_1E_3 three, $K_{2,3}$ one, F_1F_2 one, M_2E_2 three, K_1A_1 two. Total 313.

If we draw a circle 70° in radius, with its centre 180° east or west long. and 60° north lat., it will be seen that this passes through the most active seismic regions in the world. This circle is drawn on the map as a line. If it is replaced by a band 40° in width, it contains 186 entries out of the 313.

List of Earthquakes 1899-1903 *inclusive.*

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt. D = destructive
		h. m.			
1899					
Jan. 12	247	8.0	F_2	128 E. 2 N.	Halmahera, F.
,, 14	248	2.37±2	A_2	110 W. 20 N.	
,, 22	249	8.14	K_5	21.30 E. 37 N.	Greece, Philiatri, Laconia, Kyparissia, D.
,, 24	250	23.45	B	99 W. 17 N.	Mexico Republic, Vera Cruz to St. Blas, Oaxaca, D.
,, 30	251	17.45	F_3	90 E. 0 N.S.	
,, 31	252	11.12	H	28 W. 35 N.	
Feb. 23	254	13.36±7	H	25 W. 45 N.	
,, 26	255	13.36±2	H	25 W. 45 N.	

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
		h. m.			
1899					
Feb. 27	256	11.17±2	H	20 W. 52 N.	
,, 27	257	15.21±3	H	22 W. 50 N.	
,, 28	259	19.33±3	J	10 E. 70 N.	
March 7	263	0.53	$E_{1, 2 \& 3}$	136 E. 33.8 N.	Japan, F.
,, 12	264	9.37±2	B	103 W. 17 N.	
,, 21	267	14.31±4	E_2	149 E. 24 N.	
,, 23	268	10.23±5	D_2	67 W. 20 S.	
,, 23	269	14.26±2	C_1	59 W. 22 N.	
,, 25	270	14.27±3	B	87 W. 10 N.	
April 12	278	17.23	D_2	67 W. 28 S.	Rioja, Catamarca, Tucuman, D.
,, 13	279	3.36	D_2	67 W. 29.5 S.	
,, 16	282	14.38	A_1	138 W. 58 N.	
,, 17	283	1.36±3	M_1	167 W. 27 S.	
May 8	286	3.11±4	M_2	170 E. 20 N.	
June 5	291	4.30±2	B, D_1	85 W. 0 N.S.	
,, 5	292	15.2	C_1	73 W. 23 N.	
,, 14	294	11.6	C_1	77 W. 18 N.	Jamaica, Cinnamon Hill, F.
,, 17	295	1.8	E_1	145 E. 40 N.	
,, 24	298	16.57	F_3	97 E. 1 N.	Tapanoeli, Sumatra, F.
,, 29	299	22.52	F_3	97 E. 1 N.	Tapanoeli, Sumatra, F.
July 7	303	8.38±2	D_1	90 W. 10 S.	
,, 9	305	19.8±2	G_1	65 E. 5 S.	
,, 11	307	7.29±3	E_2	140 E. 15 N.	Dual Eqke.
,, 11	307*b*	7.36±3	H	42 W. 35 N.	
,, 12	308	1.35±2	H	20 W. 0 N.S.	
,, 14	308*b*	13.34±2	A_1	150 W. 60 N.	Dual Eqke.
,, 14	309	13.40	O	33 E. 23 N.	Distance A, to O. 98°
,, 17	310	10.0*ca*	F_1	130 E. 5 N.	Amboina F at 9.54 ?
Aug. 2	321	15.16	C_1	76 W. 23 N.	
,, 2	322	17.57	C_1	90 W. 25 N.	
,, 4	324	4.43	F_1	120 E. 8 N.	
,, 17	326	20.38	G_1, K_5	56 E. 16 N.	
,, 24	332	15.9±5	F_1, M_1	165 E. 27 S.	
Sept. 4	333	0.20	A_1	140 W. 59 N.	Yakutat Bay, D.
,, 4	334	4.53±2	A_1	140 W. 59 N.	,, ,,
,, 10	337	17.0	A_1	140 W. 59 N.	,, ,,
,, 10	337*b*	20.43	A_1	140 W. 59 N.	,, ,,
,, 10	338	21.38	A_1	140 W. 59 N.	,, ,,
,, 16	341	5.14	A_1	140 W. 59 N.	,, ,,
,, 17	342	12.51	A_1	140 W. 59 N.	,, ,,
,, 20	343	2.11±2	K_5	27.5 E. 37.5 N.	Aidin, Meander Valley Smyrna, D.
,, 23	344	11.4	A_1	140 W. 65 N.	
,, 23	345	13.43±2	A_1	133 W. 55 N.	
,, 27	346	8.1	H	40 W. 9 N.	
,, 29	347	17.1	F_2	129 E. 4 S.	Ceram Ambon, D.
Oct. 13	351	15.13±2	M_2	178 E. 15 S.	
,, 13	352	17.28±2	F_1	173 E. 10 S.	
,, 19	354	9.16±2	F_1	148 E. 5 S.	
,, 24	355	3.57	F_2	124 E. 9 S.	Koeheng Timor, F.
Nov. 12	358	23.43	F_1	162 E. 25 S.	
,, 18	361	14.55±3	C_2	65 W. 3 N.	

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
		h. m.			
1899					
Nov. 23	364	9.42±2	Q	160 E. 30 N.	
,, 24	365	9.56±3	F_1	128 E. 0 N.S.	
,, 24	366	18.39	F_1	136 E. 5 N.	Double Eqke.
,, 24	366*b*	18.41	E_2	131 E. 33 N.	Origin Kyushu, Japan
Dec. 25	371	12.25	A_2	117 W. 34 N.	San Jacinto, S. California, F.
,, 26	372	0.23	H	42 W. 30 N.	
,, 31	373	10.50	K_4	42 E. 42 N.	Akhalkalaki, D.
,, 31	374	20.19±2	$G_{1,2}$	68 E. 3 S.	
1900					
Jan. 5	376	18.56	F_3	102.5 E. 3 S.	Palembang, Sumatra, F.
,, 11	377	9.5±5	F_1	148 E. 5 S.	
,, 13	378	9.52±3	M_1	148 E. 48 S.	
,, 15	379	19.46±2	H	40 W. 5 N.	
,, 20	381	6.32	B	108 W. 19 N.	Mexico, Colima, Jalisco, Guerrero, D.
,, 29	383	22.30±3	G_2	82 E. 10 S.	
,, 31	385	18.50±3	M_2	178 E. 0 N.S.	
Feb. 3	386*b*	4.15±5	F_1	126 E. 2 N.	Akhalkalaki, D., also had shocks about this time.
,, 20	390*b*	21.36	G_2	80 E. 19 S.	
,, 26	391	3.41	A_1	140 W. 59 N.	
March 6	392	18.0	O	33 E. 28 N.	Cairo, F.
,, 9	394	2.18	M_2	168 E. 8 S.	
,, 12	397	1.32	E_1	142 E. 38 N.	N.E. Japan, Akita, Yamagata, F.
April 24	404	23.14	E_3	126.5 E. 27 N.	S.W. Japan, and Formosa and Oshima, F.
,, 30	404*b*	20.17	G_1	48 E. 12 N.	
May 11	405	17.21	E_1	144 E. 39 N.	N.E. Japan, Ishinomaki, F.
,, 16	407	20.13	B	105 W. 20 N.	Mexico, Colima, Jalisco, also Mexico City, D.
,, 26	408	15.59±3	L	0 E. & W. 60 S.	
June 9	411	12.11	E_3	130 E. 30 N.	Kiushiu.
,, 12	414	20.15±5	F_1	135 E. 0 N.S.	
,, 16	415	14.43±3	B	90 W. 3 N.	
,, 21	417	20.56±2	B	86 W. 15 N.	
July 15	422	18.49±2	C_2	70 W. 12 N.	
,, 29	424	6.59±3	M_2	178 W. 8 S.	
Aug. 5	425	4.18	E_1	144 E. 39 N.	Japan, Ishinomaki, F.
,, 13	427	20.13±2	F_1	137 E. 2 N.	
,, 28	430	10.59±3	J	10 W. 68 N.	
,, 29	431	2.32	E_1	145 E. 42 N.	
Sept. 1	432	7.56±1	D_1	94 W. 10 N.	Mexico, Ometepec, Coast of S. Luis Allende, F.
,, 9	433*b*	22.48	G_2	84 E. 0 N.S.	
,, 17	435	21.45±2	M_2	148 E. 5 S.	Herbertshöhe, Bismarck Archipel. F.
,, 20	438	18.57±3	F_1	136 E. 5 N.	
Oct. 7	441	21.0	F_1	130 E. 0 N.S.	
,, 8	441*b*	8.42±2	F_1	155 E. 12 S.	

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
		h. m.			
1900					
Oct. 9	442	12.27	A_1	132 W. 55 N.	Prince William Sound, Alaska, D.
,, 10	443	3.6±3	G_1	60 E. 16 N.	
,, 17	444	11.2	A_1	132 W. 55 N.	Prince William Sound, Alaska.
,, 29	445	9.26	C_2	68 W. 11 N.	Caracas, San Casimiro, Cua, D.
Nov. 5	446	7.39	E_2	139 E. 34 N.	Omori gives 139.5 E. 33.43 N. Izu, F.
,, 9	447	16.7±2	B	96 W. 11 N.	Dual Eqke.
,, 9	448	17.52	E_2	139 E. 34 N.	Nagatsuro, Izu., F.
,, 12	448*b*	1.6	F_1	147 E. 3 N.	
,, 24	450	7.54	E_1	148 E. 40 N.	Nemuro, F.
Dec. 18	452*b*	22.4±2	L	125 W. 67 S.	Dual Eqke.
,, 18	452	23.15±2	A_2	120 W. 27 N.	
,, 25	454	5.2±3	E_2	146 E. 27 N.	This may be dual.
1901					
Jan. 7	455	0.30±5	D_1	82 W. 2 S.	
,, 8	456	19.38±2	F_3	92 E. 6 S.	Malabar, Java, F.
,, 13	458	22.36±3	E_1	145 E. 42 N.	Awomori, Japan, F.
,, 18	460	4.41*ca*	A_1	135 W. 60 N.	
Feb. 15	468	8.12±1	F_2	95 E. 8 S.	
,, 20	468*a*	9.36±4	F_1	152 E. 3 N.	
March 3	470	7.45±1	A_2	120 W. 35.30 N.	
,, 4	471	16.12±3	F_2	113 E. 12 S.	Bima, Soembawa, F.
,, 5	472	10.45±2	A_2	120 W. 23 N.	But Robbles, California, is 35° N., F.
,, 16	474	11.56±2	O	40 E. 10 S.	
,, 18	475	23.24*ca*	E_1	159 E. 50 N.	Two shocks.
,, 19		23.46±2	E_1	159 E. 50 N.	Nemuro, F. at 23.50.
,, 23	476	14.10±3	P	170 E. 55 N.	
,, 31	479	7.11	K_7	28.30 E. 44 N.	
April 5	483*b*	21.53±2	F_1	130 E. 2 N.	Todano, Celebes, F.
,, 5	483	23.32	E_1	149 E. 44 N.	Japan, Nemuro, F.
,, 6	486	20.55±3	K_1	132 E. 55 N.	
,, 27	492*b*	4.5	G_2	75 E. 12 N.?	
May 14	493	6.49	E_1	148 E. 42 N.	Nemuro, F.
,, 25	496	0.32±2	M_2	165 E. 12 N.	
,, 26	497	7.40	D_1, D_2	63 W. 15 S.	
,, 27	498	16.25±3	C_1	70 W. 20 N.	
June 7	500	0.3	E_3	121 E. 23 N.	Formosa, Giran, D.
,, 13	502	3.19±2	P, E_1	160 E. 52 N.	
,, 24	505	7.3	E_3	135 E. 25 N.	Omori gives 130 E. 28 N., 7.6 G.M.T. at Tokio. Loo Choo, Oshima, F.
Aug. 6	513	18.39±3	G_1, K_5	55 E. 20 N.	
,, 9	514	9.21	E_1	144 E. 40 N.	Japan, Miyako, Kushiro, F.
,, 9	515	13.1±1	F_1	159 E. 20 S.	
,, 9	516	18.32	E_1	144 E. 40 N.	Japan, Miyako, Hakodate, F.
,, 10	517	10.27±3	F_1	155 E. 5 S.	
,, 11	518	14.32±2	M_2	178 E. 23 S.	
,, 18	519	2.5±4	S of F_3	92 E. 17 S.	
Sept. 7	529	22.34±2	F_2	125 E. 5 S.	Celebes, Tontoli, F.

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
		h. m.			
1901					
Sept. 8	530	17.42±2	F_1	170 E. 11 S.	
,, 10	532	4.26±1	F_3	90 E. 7 N.	
,, 30	534	10.6±2	Q	170 E. 30 N.	
Oct. 8	536	2.16±2	B	90 W. 7 N.	
,, 11	537	2.56±3	D_1	85 W. 7 S.	
,, 15	539	13.23±2	A_1	134 W. 53 N.	
,, 17	542	5.57±2	K_3	70 E. 30 N.	
,, 19	543	9.0*ca*	F_3		Origin near Java, many shocks.
,, 29	548	8.42	K_6	19 E. 44 N.	Raca, Servia, F.
Nov. 8	551	6.3	E_1	150 E. 40 N.	
,, 13	555	10.16	F_1	122 E. 0 N.S.	
,, 14	555*b*	4.35±1	A_2	117 W. 37 N.	Oasis, Beaver, Salt Lake City, U.S.A., F.
,, 15	557	20.15	M_1	173 E. 43 S.	Cheviot, New Zealand, D.
,, 18	558	0.4	K_3	77 E. 32 N.	
,, 20	560	23.57	A_1	130 W. 50 N.	
,, 25	562	1.51	F_1	127 E. 3 N.	Ternate, F.
Dec. 9	564	2.17±2	A_2	120 W. 23 N.	
,, 14	565	22.54	E_3	121 E. 14 N.	Batangas, Philippines, D.
,, 26	568*b*	9.58±2	M_1	140 E. 58 S.	
,, 30	569	22.34	P	160 W. 52 N.	Kenai, Alaska, D.
,, 31	570	5.51	Q	130 W. 10 N.	
,, 31	571	9.0±2	P	173 W. 41 N.	
1902.					
Jan. 1	572	6.20±2	P	165 W. 47 N.	
,, 12	574	22.24	F_3	100 E. 15 S.	About 22h.0 Eqke. at Donggala, Tontoli and Sakitta.
,, 16	576	23.53	B	99 W. 17 N.	Chilpancingo, D.
,, 18	578	23.23±2	B	94 W. 16 N.	
,, 21	580	21.40±2	C_2	71 W. 3 N.	
,, 24	581	23.23±3	F_1	161 E. 8 S.	
,, 28	582	18.48±2	C_1	68 W. 20 N.	
,, 30	584	13.59	E_1	145 E. 43 N.	Japan, Tokachi, F.
,, 31	585	1.41	E_1	145 E. 43 N.	,, ,,
Feb. 9	586	7.43±3	M_1	171 W. 43 S.	
,, 9	586*b*	10.12±3	M_1	171 W. 43 S.	
,, 13	588	9.34.6 or 9.39	K_4	50 E. 41 N.	Shemaka, D.
,, 17	589*a*	0.39±2	C_1.	70 W. 20 N.	
,, 25	590	15.35±2	F_1	127 E. 0 N.S.	
March 1	592	0.13	E_3	122 E. 24 N.	Formosa, Taihoku, F.
,, 5	593	19.3±3	D_2	83 W. 20 S.	
,, 12	596	15.7	L	160 W. 60 S.	
,, 17	597	11.22	A_2, B	109 W. 30 N.	
,, 20	598	1.50?	E_3	122 E. 24 N.	
,, 22	599	22.12±2	Q	140 W. 23 N.	
,, 24	600	17.58±2	C_1	80 W. 31 N.	
,, 25	600*b*	3.26±3	B, D_1	87 W. 3 N.	
,, 28	601*c*	14.43	F_1	130 E. 3 N.	Halmahera, Banda, F.

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
		h. m.			
1902					
April 11	605*a*	23.41	K_1	110 E. 50 N.	Double quake. Distance between origins 155°.
,, 11	605*b*	23.55	D_2	65 W. 27 S.	
,, 19	606*a*	2.22	B	91.30 W. 15 N.	Amatitlan, Guatemala, D.
,, 19	606*b*	2.34±3	G_2	60 E. 35 S.	Origin determined from Wellington, Perth, Capetown, Bombay, Kodaikanal, Calcutta, and Batavia.
,, 19	606*c*	2.36	W. of E_2.	113 E. 27 N.	Origin determined from Tokio, Manila, and Irkutsk.
,, 21	606*d*	17.26	G_2	68 E. 40 S.	
May 2	607	11.29	E_1	144 E. 39 N.	Awomori, Japan, F.
,, 8	609	2.19	E_3	132 E. 30 N.	S. E. coast of Kiushiu, F.
,, 25	610	17.20*ca*	K_2		Western Asia.
June 11	612	6.10	K_1	142 E. 53 N.	
,, 16	613*b*	1.36	K_3	79 E. 29 N.	
July 5	616	14.59	K_7	23 E. 40 N.	Bani, Salonica, D.
,, 6	617	13.1	M_3	160 W. 31 S.	
,, 9	618	3.38	K_5	56 E. 27 N.	Bander Abbas, Kishim Id., D.
,, 20	619	8.49	H	25 W. 5 S.	
Aug. 2	619*b*	14.13±2	M_2	150 E. 0 N.S.	
,, 7	621*b*	11.46	F_2	108 E. 4 S.	Palembang, Batavia, F.
,, 16	624	8.0±3	F_1	165 E. 15 S.	
,, 21	625	11.17	E_3	124 E. 8 N.	Centre of Mindanao, D.
,, 22	626	3.1	K_1, K_2, K_3	75 E. 40 N.	Kashgar, Artush, D.
,, 23	631	12.58±2	K_1, K_2, K_3	79 E. 41 N.	
,, 24	632	1.45	K_1, K_2, K_3	75 E. 40 N.	
,, 29	635	15.4	K_1, K_2, K_3	75 E. 40 N.	
,, 30	636	21.47	K_1, K_2, K_3	76 E. 40 N.	
Sept. 16	639	10.54	E_2, F_1	122 E. 6 N.	Solo and Basilan, F.
,, 20	640	6.30	K_3	70 E. 37 N.	Srinagar, F.
,, 22	641	1.44	E_2	130 E. 13 N.	Guam, D.
,, 22	641*b*	1.46	K_1	175 E. 75 N.	Determined by Irkutsk, Victoria, Toronto, and European stations.
,, 22	641*c*	1.56	M_1	152 E. 52 S.	Determined by 'Discovery,' Christchurch, Wellington, and Perth.
,, 23	642	20.16	B	90 W. 15 N.	Mexico, Tuxtla, F.
,, 23	642*b*	20.29*ca*	G_2	77 E. 60 S.	Origin determined from Perth, Batavia, Mauritius, and Capetown.
,, 24	642*d*	4.54	C_1	80 W. 31 N.	

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
		h. m.			
1902					
Oct. 2	643	17.48	A_1	145 W. 58 N.	
,, 6	644	9.10	K_3	72 E. 38 N.	Ferghana, D.
Nov. 4	653	11.35	K_2, K_3	91 E. 32 N.	
,, 15	655	9.30	E_3	128 E. 28 N.	Origin determined from Tokio, Manila, and Irkutsk.
,, 15	655*b*	9.33	F_2	105 E. 20 S.	Origin determined from Bavaria, Kodaikanal, 'Perth, Capetown, Discovery.'
,, 17	656	0.36	E_3	121 E. 14 N.	Batangas, D.
,, 20	658	20.32	E_3	121 E. 21 N.	North of Philippines. Another eqke. near Christchurch at same time, determined from Christchurch, Perth, and Batavia.
,, 21	659	7.3	E_3	120 E. 21 N.	Batanes Is. and Taito, F.
Dec. 12	661	23.5±2	A_2, B	118 W. 23 N.	
,, 13	662	17.8±2	K_3	85 E. 30 N.	
,, 16	663	5.8	K_2	75 E. 42 N.	Andijan, D.
,, 28	666	1.41	K_1	88 E. 52 N.	Bijsk, Altai Mts., D.
1903.					
Jan. 4	668	4.55±5	D_2	83 W. 15 S.	Origin determined from Christchurch, Toronto, Victoria, B.C., England, Capetown, and Mauritius.
,, 4	668*b*	5.17	E_3	120 E. 13 N.	Origin determined from Manila, Irkutsk, Perth, and Bombay.
,, 5	670	21.59	E_3	124 E. 34 N.	Chinnampo, S.W. Korea, F.
,, 14	671	1.44	B	90 W. 3 N.	Suggested by Indian, Siberian stations and Batavia.
,, 14	671*b*	2.46	K_5, G	64 E. 24 N.	
,, 17	672	16.12	C_1	88 W. 25 N.	
,, 19	673	12.36	F_1	140 E. 1 N.	
,, 24	674	5.25±3	A_2	120 W. 27 N.	
,, 24	675	15.37±2	D_1	86 W. 5 S.	
Feb. 1	676	9.33	K_2	102 E. 42 N.	
,, 2	676*b*	9.30*ca*	D_1	100 W. 15 S.	
,, 5	678	18.26*ca*	M_2	178 W. 8 N.	Origin determined from Victoria, Irkutsk, Batavia, Calcutta, Kodaikanal, Bombay, and England.
,, 6	679	7.33	K_1	98 E. 50 N.	
,, 10	681	2.48±2	E_2	142 E. 11 N.	Agana, Guam, D.

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
		h. m.			
1903					
Feb. 11	682	16.5	F_2	119 E. 8 S.	Bima, Soembawa, F.
,, 12	683	18.42	K_2	87 E. 40 N.	
,, 24	685	17.33	F_1	152 E. 8 S.	
,, 27	686	0.44	F_3	104 E. 5 S.	Tais, Sumatra, F.
,, 28	687	9.50	C_1	81 W. 20 N.	Origin determined from Trinidad, Toronto, Victoria, British stations and Bombay. Wellington does not agree, perhaps another quake.
March 12	689	14.19	K_1	87 E. 54 N.	Kuznesk, D.
,, 15	690	14.13	A_1	128 W. 51 N.	
,, 22	692	14.35	K_3	60 E. 35 N.	
,, 25	694	22.27	O	27 E. 27 N.	Origin determined from Tiflis, Tashkent, Shide and Capetown.
,, 28	696	7.55	K_2	72 E. 40 N.	Ferghana, Marghilan, Kojend, D.
,, 29	698	16.28*ca*	D_2?		Argentina, F.
,, 30	699	3.23	F_3	126 E. 3 S.	Boeroe, Masarete, F.
April 3	700	10.32	P	157 W. 57 N.	
,, 12	703	3.13±3	Uncertain		
,, 28	704	23.40	K_4	43 E. 39 N.	Melazghird, L. Van, D.
,, 29	705	3.59±4	M_3	143 W. 43 S.	
May 13	707	6.32	M_2, E_2	142 E. 8 N.	
,, 15	708	11.41*ca*	M_2, E_2	142 E. 12 N.	Determined from Manila, Tokio, Irkutsk, Calcutta and Perth. Honolulu and Victoria do not agree.
,, 17	709	1.0	K_3	80 E. 23 N.	This origin does not agree with records for Perth, W.A.
,, 23	710*a*	20.7	F_2	110 E. 8 S.	Determined from Batavia, Perth and Mauritius.
,, 23	710*b*	22.7	E_3	126 E. 7 N.	Davao, Mindanao, F. Determined from 'Discovery,' Manila, Tokio, Irkutsk and European stations.
,, 29	714	9.33	K_5	20 E. 39 N.	Corfu, F.
June 2	717	13.10±2	K_1, A_1	170 W. 67 N.	
,, 4	718	15.12±5	O	37 E. 23 N.	
,, 7	719	9.5	E_2	122 E. 21 N.	Batanes Ids., F.
,, 8	721	5.23±3	M_1	121 E. 50 S.	
,, 10	724	16.31	F_1	149 E. 0 N.S.	
,, 24	734	16.56	K_4	49 E. 39 N.	Lenkoran, F.
,, 25	736	22.12	K_1	96 E. 51 N.	
July 2	738	21.22	M_1	150 E. 50 S.	
,, 12	746	5.27?	F_1	150 E. 5 S.	
,, 23	748*b*	22.36	E_2	121 E. 19 N.	Luzon, Aparri, F.

List of Earthquakes 1899-1903 *inclusive*—continued.

Date	No.	Time at origin	District	Lat. and long. in degrees	Remarks. F = felt, D = destructive
		h. m.			
1903					
July 27	750	10.34	H	57 W. 33 N.	
,, 27	751	12.32*ca*	H	57 W. 33 N.	
Aug. 11	759	4.30	K_6	23 E. 36½ N.	Greece, Potamos, Mytata, D.
,, 13	760	15.46	E_1	146 E. 41 N.	
,, 16	761	13.35±5	C_1	72 W. 20 N.	Jamaica, Unity, F.
Sept. 7	764*a*	7.10	M_1	175 E. 71 S.	Determined from Christchurch, Perth, and Honolulu.
,, 7	764*b*	7.14	E_3	122 E. 23 N.	Determined from Irkutsk, Krasnoyarsk, Bombay, Capetown, and British stations.
,, 8	765	5.7	L	78 E. 50 S.	
,, 10	766*b*	13.48	A_1	130 W. 58 N.	
,, 13	767	15.31*ca*	H	19 W. 41 N.	
,, 23	769	0.14	M_1	160 E. 52 S.	
,, 25	771	1.20±3	K_3	58 E. 34 N.	Persia, Turschis, D.
Oct. 10	773	16.41	E_3	132 E. 32 N.	Japan, Hyuga, F.
,, 14	774	3.20*ca*	F_2	128 E. 11 S.	Timor, Atapoepoe, F. Determined from Manila, Perth, Batavia.
,, 19	774*b*	3.5*ca*	F_3	98 E. 3 S.	Lais, Sumatra, F.
,, 20	775	2.47	F_1	168 E. 9 S.	
,, 21	777	9.50*ca*	G_1	55 E. 33 S.	
,, 23	778	2.36	K_1	97 E. 50 N.	
,, 29	780	14.19	F_1	167 E. 20 S.	
,, 30	781	3.54	F_1	175 E. 20 S.	
Nov. 10	783	17.17	M_1	150 E. 50 S.	
,, 10	784	20.46	F_1	167 E. 17 S.	
,, 17	785	20.23±2	E_3	126 E. 9 N.	Philippines, Surigao, F.
,, 24	788	13.34	F_1, E_3	125 E. 3 N.	Celebes, Bolaang, F.
,, 26	789	11.46	K_1	110 E. 53 N.	Send, L. Baikal, D.
Dec. 1	789*b*	6.43	Q	165 E. 25 N.	
,, 1	790	14.21	E_3	120 E. 24 N.	
,, 3	791*b*	21.26	K_3	93 E. 32 N.	
,, 5	792*b*	5.7	K_1, A_1	150 W. 66 N.	
,, 6	793	22.48	G_1	45 E. 41 S.	Felt at Cairo, 23.34.
,, 7	793*b*	14.40±3	D_2	71 W. 28 S.	Chili, Vallenar, D.
,, 10	794	7.8	K_5, G_1	65 E. 21 N.	
,, 18	796*b*	12.18	E_2, M_2	135 E. 5 N.	
,, 23	798	0.53	M_2	170 E. 5 S.	Determined from Christchurch, Honolulu, Batavia, and Irkutsk. 40m. later another eqke. recorded at British and Azores stations.
,, 28	802	2.50±2	F_1, E_3	123 E. 3 N.	Celebes, Tontoli, F.

XIII. *Sensibility of Seismographs recording on Smoked Surfaces.*

On several occasions in the British Association Reports I have given illustrations of the marked want of sensitiveness of seismographs which record on smoked surfaces.[1] Instruments which work in this manner are inexpensive to maintain, you can at any time see your record, and they yield most excellent seismograms of strong disturbances. However, in consequence of the elasticity of the writing levers, and possibly for other reasons, they do not commence to give a record until a certain amplitude of motion has been reached. They therefore fail to record minute movements, and as these may frequently represent that which remains of an earthquake originating at a great distance, those who use these types of instrument are entirely cut off from what I have called a 'New Departure in Seismology.' As bearing upon this point I give the following quotations from the report of the Director, Bombay and Alibag Observatories, 1910. The italics are mine:—

Milne's Seismograms, *photographic Records.*	There was no loss of record.	The action of the instrument is voluntarily interrupted, *e.g.*, for regular changing of the film, winding and rating the watch and clock, adjustment and examination of the instrument, deflection experiments, &c.; such interruptions are not taken into consideration.
Vertical movement Seismograms.	Out of 9 principal disturbances 7 were recorded and 1 was not recorded.	1 disturbance was partially lost in shifting time.
	Out of 48 small disturbances 20 were recorded and 26 were not recorded.	2 disturbances were lost as the paper did not come out.
Colaba No. 1 (E.-W.) Seismograms.	Out of 9 principal disturbances 8 were recorded.	1 disturbance was partially lost in shifting time.
	Out of 48 small disturbances 37 were recorded and 8 were not recorded.	2 disturbances were lost in shifting time and 1 was lost owing to the *smoked paper* being destroyed.
Colaba No. 2 (N.-S.) Seismograms.	Out of 9 principal disturbances 8 were recorded.	1 disturbance was partially lost in shifting time.
	Out of 48 small disturbances 31 were recorded and 13 were not recorded.	1 was lost owing to the stoppage of clock; 2 were lost in shifting time, and 1 was lost owing to the *smoked paper* being destroyed.
Omori Seismograms.	Out of 9 principal disturbances all were recorded.	
	Out of 48 small disturbances 36 were recorded and 11 were not recorded.	1 was lost owing to the *smoked paper* being destroyed.

[1] See *Brit. Assoc. Seis. Reports*, 1909, p. 51, 'Aftershocks of the Earthquake at Jamaica'; 1910, p. 48, 'A New Departure in Seismology.'

Milne's seismograph registered *fifty-seven* earthquakes during the year under report, besides several small local and other movements. Of these, three were great disturbances—namely, those recorded on November 9 and 13 and December 16.

The seismograph for recording vertical movements registered *twenty-seven* disturbances.

The Japanese (Omori) seismograph recorded *forty-five* disturbances.

The Colaba seismographs No. 1 (E.-W.) and No. 2 (N.-S) recorded *forty-five* and *thirty-nine* disturbances respectively.