

## ON THE DISTRIBUTION OF EARTHQUAKE MOTION WITHIN A SMALL AREA.

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BY JOHN MILNE.

[Read January 24th, 1889].

Anyone who has resided for some length of time in a district shaken by earthquakes can hardly have failed in noticing that almost every observer of a shock describes his sensations and experiences differently. One observer may describe a shock as sharp and coming from the north, while his neighbour will declare that it was gentle and the movement was distinctly east and west. In another part of the same city several observers will tell you that neither they nor their families felt any earthquake whatever. On one occasion I remember a shock which was sufficiently strong to cause a number of the members of a small club situated on the east side of Tokio to seek refuge outside, while at several houses not more than three quarters of a mile distant, although careful enquiries were made, nobody could be found who had felt the disturbance.

Another instance of extremely local movement was given me by a gentleman who made enquiries from his friends as to whether they had felt a particular earthquake. One conclusion he arrived at was, that the movement had only been felt by people whose houses were along a particular line running through the city of Tokio. Observations such as these, and of which very many might be quoted, have generally been regarded as attempts to test the credulity of listeners, but the more notes I accumulated respecting the distribution of earth-

quake motion the more I became inclined to the belief that earthquake motion has often been very much more local and peculiarly distributed than is generally supposed.

My curiosity having been excited, in the summer of 1887 I determined by a rough series of tests to approximately determine the extent to which different portions of the city of Tokio were shaken in different earthquakes. To do this I distributed through the city and its suburbs, 134 bundles of post cards. Each card which was addressed to myself, had upon it in English and in Japanese the following request:—"If you or your neighbours feel an earthquake, kindly post this card, giving the *date* and *time* of the shock, and saying whether it was *short*, *long*, a *tremor* or a *jerk*; were you upstairs or downstairs?"

With each bundle, in which there were 20 cards, there was a letter of more detailed instructions. Many of these bundles were given to members of the Seismological Society or to friends whom I knew took an interest in seismological investigation. For the distribution of the greater number of my bundles of cards I must thank my friend and colleague Professor Sekiya, who took the trouble to write to a hundred or more schoolmasters and others who had a scientific training asking them whether they were willing to undertake the trouble of filling up cards when they experienced a disturbance. To those who sent a favourable reply, bundles of cards were forwarded. I particularly desire to lay stress on the method of distribution, so that it will be understood that the cards were not distributed haphazard but were given to persons who were educated and who were willing and capable of making the necessary observations. The accompanying map (No. 1), which shows a land area measuring six miles from East to West and five miles from North to South, indicates by numbers the positions of the various observers. Those on the western and northern sides of the city were mostly situated

on ground from 50 to 100 feet above sea level, while those on the southern and eastern parts of the town were living on low flat ground which is over-looked by the bluff-like terminations of the high ground. This latter part of the city is intersected by many moats and canals, and by one large river.

In a paper entitled "The Stone Age in Japan; with Notes on Recent Geological Changes which have taken place," published in the Journal of the Anthropological Institute, May, 1881, I have given four vertical sections of borings in the low ground of Tokio, and a quantity of evidence showing that during recent times at the head of Tokio bay, the land, partly by elevation and partly by silting has rapidly been encroaching on the sea.

In a paper on "Stone Implements and Prehistoric Remains in Japan," read before the Asiatic Society of Japan, November 11th, 1879, evidence that the low ground of Tokio is of comparatively recent origin is supplemented with a map showing how since A.D. 1028 the coast line has progressed southwards.

The following are a few examples of vertical sections in different parts of Tokio which I have taken from an account of the geology of Tokio, kindly furnished to me by Mr. Y. Wada, Director of the Geological Survey.

The position of some of these sections are indicated on Map No. 1 by letters corresponding to the alphabetical order given with the sections.

The depths given are in shaku (1 shaku=0.994 ft.) and indicate the depth at which any particular layer terminates, reckoned from the surface.

A.—ASUKAYAMA, OJI.

1. Loam .....	32.5
2. Clay .....	37.5
3. Sand and shingle with a few patches of clay.....	102.5
4. Clay and sand with fossils .....	110
5. Tuff with fossils ...	127½
6. Tuff, no fossils .....	

B.—GONGEN, NEDZU.

1. Loam .....	35
2. {A thin layer of pumice} {Sandy loam.....}	80
{Sand and shingle...}	
3. Clay.....	82½
4. Sand and shingle ...	

**C.—OCHANO-MIDZU.**

1. Loam with a thin layer of pumice ... 50
2. Clay ..... 55
3. Sand and shingle... 95
4. Clayey tuff to 127.5

**E.—HOHEIKOSHO.**

1. Loam with thin layer of pumice ..... 37.5
2. Clay ..... 42.5
3. Sand and shingle to 62.5 .....

**G.—KIRISHITAN-SAKA,****KOISHIKAWA.**

1. Loam ..... 70
2. Clay ..... 72.5
3. Sand and shingle with a little clay to 100 .....

**I.—TOYOKAWA-MACHI,****TAKATA.**

1. Loam with a band of pumice ..... 62.5
2. Clay ..... 65
3. Pebbles to 135 .....

**K.—AKAGI TEMPLE.**

1. Loam with band of pumice..... 60
2. Sand and shingle... 100

**M.—ATAGO, SHIBA.**

1. Loam ..... 30
2. Clay ..... 35
3. Sand and shingle... 85
4. Clay ..... 90
5. Tuff to 110.....

**D.—NISHIKATAMACHI,****KOMAGOME.**

1. Loam with thin layer of pumice..... 27.5
2. Clay..... 32.5
3. Sand and shingle to 65 .....

**F.—YAKUÖ-IN.**

1. Loam with thin layer of pumice ..... 52.5
2. Clay..... 65
3. Sand to 70 .....

**H.—ROKUTENCHO,****KOISHIKAWA.**

1. Loam with a band of pumice..... 47.5
2. Clay..... 50
3. Sand and shingle with clay ..... 87½
4. Clay to 92 .....

**J.—KAMI-TOMISAKA-CHO,****KOISHIKAWA.**

1. Loam ..... 45
2. Clay..... 54
3. Pebbles to 107.5 ...

**L.—TSUKUDO, USHIGOME.**

1. Loam with pumice... 32.5
2. Clay..... 35
3. Sand and shingle to 57.5 .....

**N.—ENOKICHO, AKASAKA.**

1. Loam with clay ..... 30
2. Clay ..... 37.5
3. Sand and shingle with clay to 85.....

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O.—MUKOJIMA.

1. Sand and earth ...	3.05	8. Sand, earth with	
2. Ditto, but more		oysters .....	26.41
sandy .....	6.80	9. Sand and earth.....	28.60
3. Ditto, with coarse		10. Ditto with clay .....	40.31
sand.....	7.90	11. Clay with sand .....	49.17
4. Coarse sand .....	11.97	12. Ditto, with coarse	
5. Sand and pebbles	13.85	sand .....	57.19
6. Sand and oyster		13. Sand and clay .....	60.39
shells .....	18.13	14. Sand .....	61.59
7. Ditto, with pebbles	23.63		

P.—NAKUSA, NEAR YEITAIBASHI.

1. Clay .....	5.50	5. Blue earth .....	16.77
2. Coarse sand .....	7.75	6. Ditto, but watery ...	19.47
3. Blue sand, clayey...	9.35	7. Soft clay .....	43.02
4. Ditto, with pebbles	14.88	8. Ditto, but harder ...	60.69

BORE HOLE IN FUKAGAWA.

Earth .....	96	Coarse sand .....	234
Shingle .....	108	Shingle .....	246
Earth and sand .....	126	Sand .....	270
Shingle .....	144	Blue clay .....	273
Loam sand .....	153	Sand .....	384
Blue clay .....	168	Blue sand .....	420
Sand .....	180	Sand .....	430
Shingle .....	222	Sand .....	546
Blue clay.....			603

Four borings near the old Naval College in Shiba, after from 5 to 8 feet of soil, give up to a depth of 40 or 50 feet alternate layers of soft mud, clay, and sand.

From these sections we may conclude that the hilly ground on the West and Northern side of Tokio which rises abruptly about 80 or 90 feet above the low ground, consists of about 40 feet of friable loam, 2 or 3 feet of clay and say 40 feet of sand and shingle. Below this we meet with the hardened clay-like tuff similar to that so well exposed near Yokohama. This tuff which may be looked upon as a soft rock, would therefore crop out near the base of the Bluffs. From this point the tuff dips down beneath the low ground, where it is covered with a thin layer of earth followed by thicker beds of sand and mud extending to a depth of several hundred feet.

The rock beneath the low ground of Tokio, with the exception of one or two places, as for instance near Shinbashi, is covered with a layer of softer material than that which covers it on the hills, and this layer is about twice the thickness of that upon the hills.

On map No. 1 a natural section is given two *ri* in length extending from the high ground to the low ground, showing the relationship of the alluvium and rock to the surface contour.

Seventy-five observers were situated on high ground and fifty-nine on low ground. In addition to the regular postcard observation, I occasionally received notes from friends especially interested in earthquakes, and the records from the Chirikoku (Imperial Meteorological Bureau) where there is a well equipped seismological observatory and several officers whose duty it is to attend to the registration of earthquakes. Another observatory on the high ground is that of Professor Sekiya. I also received occasional communications from friends living on the low ground and from Professor Sekiya's second observatory situated at Hitotsubashi. The total number of my correspondents therefore amounted to nearly 150.

Before proceeding to the enumeration of the records which were obtained, which commenced on November 15th, 1887, and terminated in May 6th, 1888, it is necessary to epitomize several important results respecting the distribution of earthquake motion obtained during previous years without which, to the majority of readers the records might in many instances appear as a series of contradictory observations.

#### OBSERVATIONS POSSIBLY EXPLANATORY OF THE DISTRIBUTION OF EARTHQUAKE OF MOTION IN TOKIO.

The first, and so far as I am aware the only, experiments having a definite relation to and possibly explanatory of the observations made in Tokio are a series of experiments which extended over a period of two years, which I described under the title of a Seismic Survey (Trans. Seis. Soc., Vol. X. p. 1 to 36.)

The object of these experiments was to determine on a piece of ground about 900 feet in diameter, how far the motion of a given earthquake recorded upon one portion of it differs from that recorded upon other portions. The results obtained were exceedingly astonishing. On one side of the ground the motion might be quick and small, while on the other side, which was relatively soft, the motion was slow and large. No two parts of the same area yielded identical diagrams of the same disturbance, in fact they were at times so different that it appeared possible that an indifferently built house on one side of the area might be shattered whilst on the other side a similar house might remain unhurt. The instruments employed were in every way similar and when placed side by side they yielded, either for actual earthquakes or for artificial disturbances, like results. These observations explained why diagrams of earthquakes obtained by residents on the low ground near the centre of Tokyo were always larger than those obtained by persons like myself situated upon the high ground. Amongst the many other results yielded by these experiments it was shown that earthquakes with a long period, although the amplitude might be large, might pass across an area without attracting the attention of persons unprovided with instruments. A remarkable example among many disturbances of this description which I have called slow earthquakes was one recorded on March 25th, 1884, which although it yielded a remarkably fine diagram, was not, so far as I can learn, felt by any of the many people who resided near me—one or two persons, however, observed that at the time of the disturbance lamps were swinging. Another result demonstrated by actual measurement was, as might be anticipated, that the diagrams indicating the longest period had been recorded upon the softest ground, and we might therefore conclude that it would be upon the softest ground where people would have the greatest chance of being moved back and forth without noticing any motion. In moderately severe earthquakes, however, the range of motion was on

soft ground so much greater than it was upon hard ground, that so far as destructive motion (acceleration) was concerned this became more than it was upon hard ground.

From this it might be argued that moderately severe earthquakes passing across the whole of Tokio would be felt as much upon the soft low ground as they would upon the hard, dry ground. For very small earthquakes, however, still resting our argument upon results obtained from the Seismic survey, this same law will not hold, because with small earthquakes it was sometimes found that the record for amplitude and acceleration was less than that obtained upon hard ground. In these cases it appeared as if the soft ground absorbed the motion. This would lead to the conclusion that small earthquakes might not be felt upon the low soft ground of Tokio while they might be felt upon the high ground which is hard. Another observation which also bears upon the results to be described in this paper is that the experiments made in the seismic survey distinctly showed that at any given station there was a relation between period and amplitude, the period increasing very rapidly with the amplitude until the amplitude became large, after which the period ceased to increase or only increased very slowly. On different kinds of ground it is probable that this relationship between period and amplitude will be different, and it is not unlikely that upon hard ground the critical point when period practically becomes constant will be reached much more quickly than it is upon soft ground, but on soft ground the maximum period will have a far greater amplitude than will be experienced for the maximum period on hard ground. Farther, although the maximum period in soft ground may be greater than the maximum period reached upon hard ground, the amplitude of motion in the soft ground will so far as destructive effect is concerned more than counterbalance the destructive effect on hard ground where although the period is short the amplitude of motion is more than correspondingly small.



In large earthquakes the destructive effect on soft ground may therefore be greater than it is on hard ground, whilst small earthquakes may not be recorded on the soft ground. A somewhat similar series of results respecting the relation of amplitude to period are indicated in a paper on Seismic Experiments (Trans. Seis. Soc., Vol. VIII., p. 1-82).

In interpreting the observations made in Tokio, although we are all aware that when a moderately destructive shock has occurred in Yokohama it has always been the houses on the hills or hard ground which have most severely suffered, it must be remembered that this is contrary to general experience. At the time of the great Lisbon earthquake, the destruction of Port Royal, the Ansei earthquake in Tokio, the earthquakes at Cassamicciola, and in fact in nearly all great disturbances the buildings on the low soft ground have almost invariably suffered most severely.

A set of observations which have been of value in approximately determining the area over which a shock of any magnitude has extended, are those made at the Meteorological Bureau (Chirikioku).

In 1881 I distributed bundles of fresh cards over the Northern portion of the Japanese Empire much in the same way as post cards were distributed over Tokio. ("On 387 earthquakes, observed during two years in North Japan, by John Milne.—Trans. Sei. Soc., Vol. VII., Part II., p. 1-87.") From the records received I was able to draw maps showing the area over which any given shock had extended, and in this way to determine the portions of northern Japan which were most shaken. This work has now been undertaken by the Meteorological Bureau in Tokio who have now more than 600 post card stations distributed throughout the Empire.

From these records, which the Director of the Observatory Mr. Arai Ikunosuke, has kindly placed at my disposal, I have in many instances been able to state whether a shock was only felt in Tokio or whether it was a shock having a wide distribution. The area over which a shock has been felt is given in square *ri* (1 square *ri* = 5.95 square miles). With these preliminary observations I will now proceed to an enumeration of the records.

## OBSERVATIONS ON EARTHQUAKES

Felt in different parts of Tokio in 1887-1888, the records being obtained from post-cards.

I.—NOVEMBER 15TH, 1887.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
65	Kōjimachi.	4.5 p.m.	feeble	long	Upstairs.
116	Kōjimachi.	3.55 p.m.	very feeble	—	Ground floor.
109	Tsukiji, French Legation.				Not felt.
54	Yotsuya ...	3.55 p.m.	feeble	about 1m.	Ground floor.
6	Kōjimachi.	? 5.00 p.m.	very feeble	short	Ground floor ; only felt by two out of six persons present.
4	Akasaka ...	4.00 p.m.	feeble	long	Ground floor.
108	Azabu .....	3.54.20 p.m.	feeble	slow vibrations for 30s.	Ground floor.
3	Azabu .....	3.55 p.m.	feeble	35s.	Ground floor.
	Hongo, Sekiya ...	3.52.28 p.m.			
	Hitotsuba- shi, Sekiya	3.52.28 p.m.			
	Kokadai- gaku .....		amp .2mm.		A long slow mo- tion (Milne).
	Chirikioku.	3.54.51 p.m.	amp .4mm. period 2.4	2m.	Direction E. 26° 30' S.

This earthquake was not felt at Chōoji, Takanawa, or in Shinagawa, or by any of the servants in the French Legation, No. 18, Tsukiji.

It was felt in Iidamachi, Kojimachi, also at No. 9, Torizaka, Azabu.

This earthquake is one which extended over a large area of country (1,460 square *ri*) and therefore it might be expected that it ought to have been recorded by the greater number of observers living in Tokio. As a matter of fact it was only felt at 10 places, and these are all situated on the high ground on the western side of Tokio or along a north and south line

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extending from Shiba in the south to Yotsuya and Koishikawa in the north. It was also recorded at three observatories. The probable explanation for this curious distribution of motion that was sensible lies in the fact that the wave frequency (4 waves in 10 sec.) was small or the period of any given wave was long (nearly  $2\frac{1}{2}$  seconds). On the hard high ground, the period being a little quicker than on the soft low ground, it was only those living on the high ground who noticed the movement.

2 AND 3.—NOVEMBER 20TH.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
123	Azabu .....	0.3 p.m.			
28	Fukugawa.	0.6 p.m.	pretty strong	10s.	Ground floor.
28	Kanda ...	0.3 p.m.	pretty strong	30-40s.	Upstairs.
44	Fukagawa.	0.1 p.m.	feeble	1m.	Ground floor.
45	Fukagawa.	0.2 p.m.		? 3m.	Upstairs.
86	Honjo .....	0.5-30 p.m.	feeble	2s.	Ground floor.
84	Honjo .....	0.4 p.m.	feeble	2m.	Ground floor.
84	Honjo .....	0.4 p.m.	feeble	2s.	Ground floor.
35	Honjo .....	? 11.57 a.m.	feeble	5s.	Ground floor.
41	Honjo .....	0.3 p.m.	feeble	20s.	Ground floor from north-east.
46	Honjo .....	0.3 p.m.	feeble	very short	Ground floor.
78	Honjo .....	0.5 p.m.	pretty strong	5-6s.	Ground floor.
80	Honjo .....	11.50 a.m.	feeble	2m.	Ground floor.
87	Asakusa ...	0.1 p.m.	feeble	30s.	Ground floor.
89	Honjo .....	0.2 p.m.	pretty strong at first and feeble afterwards	40s.	Ground floor from south-west.
63	Kyobashi..	0.5 p.m.	feeble	30s.	Upstairs.
75	Asakusa ...	0.2 p.m.	very feeble	4s.	Upstairs.
76	Asakusa ...	0.2-3 p.m.	feeble	1-2m.	Ground floor from south-west.
70	Shitaya ...	0.3 p.m.	very strong at first and feeble at the end	30s.	Ground floor from south-east to north-west.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
70	Shitaya ...	0.2.30 p.m.	very strong at first and ending feeble	15s.	Ground floor from north-west.
70	Shitaya ...	0.5 p.m.	very feeble	1m.	Ground floor.
72	Shitaya ...	0.4 p.m.	pretty strong	40s.	Ground floor.
72	Shitaya ...	0.2 p.m.	feeble	40s.	Ground floor.
52	Shitaya ...	0.3 p.m.	pretty strong	about 30s.	Ground floor.
58	Hongo ...	0.0 p.m.	pretty strong	about 3m.	Ground floor.
92	Kanda ...	0.8-9 p.m.	pretty strong	about 1m.	Upstairs.
104	Kanda.....	0.3 p.m.	tremor	1m.	Downstairs.
64	Koishi-kawa.....	0.5 p.m.	strong at first	about 20s.	Ground floor.
64	Koishi-kawa.....	0.2.1 p.m.	strong	short 3s.	Ground floor from north-south.
68	Koishi-kawa.....	0.5 p.m.	pretty strong	5s.	Ground floor from north-east.
33	Kanda ...	0.2 p.m.	very feeble	5s.	Upstairs.
35	Honjo.....	0.3 p.m.	slow	30s.	Ground floor on hill at Omori. But the same was the case at No. 35.
36	Kanda ...	0.3 p.m.	pretty strong	10s.	Upstairs.
42	Kanda ...	0.4.35 p.m.	strong	20s.	Downstairs from north-west.
67	Kanda ...	0.0 p.m.	feeble at first then strong lastly feeble	5m. 30s.	Upstairs from south-east to north-west.
67	Koishi-kawa.....	0.3 p.m.	very feeble	about 10s.	Ground floor.
31	Nihon-bashi.....	0.2 p.m.	pretty strong		Ground floor.
82	Nihon-bashi.....	0.3 p.m.	a jerk		Upstairs.
27	Kyobashi..	0.3 p.m.	feeble	about 6s.	Ground floor.
106	Kyobashi..	1.6 p.m.	jerky	25 or 30 seconds	Downstairs from E. to W.
113	Kyobashi..	0.3 p.m.	short and violent	about 2s.	
124	Kyobashi..	0.3 p.m.	tremor	about 30s.	Upstairs.

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No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
18	Kōjimachi.	0.7 p.m.	feeble	about 40s.	Ground floor.
37	Kōjimachi.	0.5 p.m.		1m.	Ground floor.
111	Kōjimachi.	0.4 p.m.			
54	Ushigome.	0.0 —	pretty strong	about 1m. 3s.	Ground floor on low marshy place.
55	Nihon-bashi .....	0.9 p.m.	pretty strong	about 1m.	Ground floor from south.
54	Yotsuya ...	0.0 —	strong	1m. 5s.	Ground floor.
54	Yotsuya ...	9.40 p.m.	very feeble	1m.	Feeble shock again at 9.40 p.m. on the same day.
95	Yotsuya ...	0.2 p.m.	feeble	3s.	Felt while walking in garden.
99	Yotsuya ...	0.1.30 p.m.	pretty strong	1m. 2-3s.	Ground floor.
4	Akasaka ...	0.2.31 p.m.	pretty strong first and ending feebly	40s.	From south to north ground floor.
4	Akasaka ...	9.55 p.m.	very feeble	slow	From south-north ground floor.
6	Akasaka ...	11.48 a.m.	feeble	2s.	From south-north ground floor.
6	Akasaka ...	0.0 p.m.	pretty strong at first	2m.	From south-north ground floor.
25	Akasaka ...	0.3 p.m.	feeble	3s.	From south-north ground floor.
1	Azabu .....	0.23 p.m.	pretty strong at first	1m.	From south-north ground floor.
2	Azabu .....	0.3 p.m.	very feeble	about 30s.	From south-north ground floor.
3	Azabu .....	0.2.20 p.m.	pretty strong	30s.	From south-north ground floor.
5	Azabu .....	0.30 p.m.	pretty strong	2m. 30s.	From south-north ground floor.
11	Azabu .....	0.3 p.m.	feeble	1m.	From south-north ground floor.
12	Azabu .....	0.1 p.m.	pretty strong at first	1ms. 30s.	From south-north ground floor.
18	Azabu .....	0.2-3 p.m.	feeble	35-36s.	Downstairs from south.
108	Shiba .....	0.3 p.m.	sharp jerk	about 10s.	Ground floor.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
8	Shiba .....	0.2 p.m.	pretty strong	20s.	
8	Shiba .....	0.1 p.m.	pretty strong	30s.	Upstairs.
47	Shiba .....	0.4 p.m.	pretty strong	70s.	Ground floor from N.E.
114	Shiba .....	0.5 p.m.	very feeble	10s.	Ground floor.
	Hongo (Sekiya).. Hitotsu-bashi (Sekiya).. Kokadai-gaku .....	0.02.31 0.02.31			
	Chirikioku	0.02.31 p.	.2 mm. amp .2 period .5	45s.	Motion chiefly E. and W. Direction N. 17° E. Very slight.
	Yokohama	9.45.00 p. at noon			

122.—At 12.2-3.0 p.m. in the English Church at Iigura, two or three slight waves followed by three or four more decided motions were felt. There was no jerk. The duration was about 8 or 10 seconds. The movement was similar at Chôoji, Takanawa.

101.—At 12.3.0 p.m., a very slight disturbance of extremely short duration was felt, the observer being downstairs (Banba-cho, Shinagawa).

105.—At 12.2.0 in the English Church at Iigura, a short sharp shock lasting about 20 sec.

108.—At 12.3.0 p.m., a sharp shock—a jerk. Duration 10 sec. The observer on the ground floor, Azabu.

115.—About noon. A tremor of short duration felt downstairs. Things shook considerably and glass and crockery rattled. No. 1, Tsukiji. Kiobashi.

116.—At 12.5.0 p.m. A tremor lasting 10 sec. felt while on the verandah downstairs. Kojimachi.

117.—At 12.3.0. A sharp shock felt downstairs.

5.—At 12.4.0 p.m. A horizontal slight shock. Movement

E.-W. Duration 1m. 30s. It was accompanied by a noise from the E. The observer downstairs. Akasaka.

107.—At 11.57.0 a.m. Apparently imperceptible to one standing, but felt distinctly while sitting on mats downstairs. Tangomachi, Akasaka.

107.—At 12.2.0 p.m. A feeble earthquake lasting about 5s. was felt while downstairs. Many people did not feel it. No. 22, Shinmeicho, Shiba.

110.—At 12.5.0 p.m. A short tremor-like disturbance. (Dutch Legation, Shiba.)

The earthquake at 0.2.31 p.m. is one which not only extended over a large area (1,360 square *ri*) but the period of movement appears to have been short. It is therefore natural that it should have been felt throughout Tokio.

As the shock at 9.45.0 p.m. was only felt at two places on the west side of Tokio and at the Chirikioku, it was probably of local origin and in no way connected with the disturbance at midday. Its area is given as 670 square *ri*.

## 4.—NOVEMBER 23RD.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
55	Ushigome.	6 p.m.	feeble	about 2s.	Downstairs.
117	Azabu .....	6 p.m.	feeble		Downstairs felt 2 slight shocks.
4	Akasaka...	6.10 p.m.	feeble	about 10s.	Downstairs.
117	Kōjimachi.	5.59 or 6 p.m.	slight tremor		Downstairs.
96	Minami Tushima..	6.5 p.m.	feeble		
	Chirikioku	6.05.00 p.			Very slight.

The Chirikioku maps only show that Tokio was shaken.

We have here another example of a shock only felt on the high ground upon the W. and N.W. side of Tokio, in Akasaka, Azabu, and Kojimachi. On the N.E. side of Tokio it seems too feeble even to have been recorded by instruments. It was not felt in districts surrounding Tokio.

## 5.—NOVEMBER 26TH.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
10	Yotsuya ... Yokohama	5.6 a.m. 4 a.m.			N.E.-S.W.

## 6.—NOVEMBER 27TH.

2	Azabu .....	2.11 p.m.	gentle tremor	5m.	Downstairs.
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Kobudaigaku—On each of two static seismographs an indication of .1 mm.

## 7.—NOVEMBER 30TH.

84	Honjo .....	9.25 a.m.	feeble	about 4s.	Downstairs.
127	Kyobashi..	9.26 a.m.	very feeble		Upstairs.
49	Ushigome.	9.22½ a.m.	feeble	about 30s.	Upstairs.
41	Minami- Katsu- shika .....	9.25 a.m.	feeble	about 30s.	Downstairs north to south.
87	Honjo .....	9.25 a.m.			Downstairs school.
85	Minami- Katsu- shika .....	9.40 a.m.	feeble	about 1 sec.	
25	Shitaya ...	9.30 a.m.	pretty strong	about 1 minute	Downstairs.
100	Hongo .....	9.28 a.m.	slight tremor		Downstairs.
60	Kita- Toshima..	9.24 a.m.	feeble	5 sec.	Downstairs school.
125	Koishi- kawa .....	9.24 a.m.	series of short shocks	30 sec.	
131	Kanda.....	9.30-10 a.m.	pretty strong		Downstairs.
31	Nihon- bashi .....	9.25 a.m.	feeble	40 sec.	This felt at Taka- rada School Kyo- bashi upstairs.
31	Nihon- bashi .....	9.15 a.m.	feeble		Downstairs.
116	English Legation, Kōjimachi.	9.21 a.m.	long tremor		Downstairs.
4	Akasaka ...	9.25 a.m.	feeble		Downstairs south-north.
112	Shiba .....	9.25 a.m.	feeble	30 sec.	



EARTHQUAKE MOTION WITHIN A SMALL AREA. 57

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
114	Shiba .....	9.28 a.m. 9.24.18 a.m.	very feeble	7 or 8 sec.	New form of pendulum machine felt at J. M. C. observatory.
	Hongo (Sekiya).. Hitotsu-bashi .....	9.24.18 9.24.18			
	Chirikioku	9.24.18	a. amp 1.3 period 1.2	1m. 30s.	S.S.E.-N.N.W.
	Yokohama	9.23.0	a.		N.E.-S.W. slight.

127.—No. 33, Tsukiji, at 9.26 a.m., a slight shock, hardly perceptible.

122.—Shiba, Chôoji, 9.25 a.m., a long, slow, slight earthquake, but as there was much wind it is not absolutely certain that it was an earthquake.

110.—Shiba, Kiridoshi, a long tremor, not very strong. There was much wind.

Kobudaigakko, Toranomom—Saw the tremor machine working violently but could not feel any motion, amplitude .3 mm.

131.—Surugadai, Suzukicho—Felt at 9.30 by a servant downstairs. It was a long tremor without jerk.

125.—The University, Hongo, at 9.24 a.m. a series of short shocks were felt while in a wooden out-building.

At No. 6, Kaga Yashiki, it was felt.

Miogadani not observed.

132.—Masagocho, Hongo, at 9.27 a.m. a tremor lasting  $1\frac{1}{2}$  minute. High Normal School, felt upstairs in large brick building, but not felt upstairs in a wooden building.

Although this shock disturbed a large area (1,710 square *ri*), in Tokio it was only practically felt along a north and south line slightly to the west of the central part of the city extending from Shiba on the south to Koishikawa on the north. The length of the period, 1.2 sec., would explain why it was

unnoticed upon the flat ground, but it does not explain why it was not felt upon the high ground towards the west. There were 6 waves in 10 seconds.

## 8.—DECEMBER 3RD.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
34	Kanda.....	4.50 p.m.	feeble	4 minutes	Downstairs.
45	Fukagawa.	5 a.m.	tremor	2 seconds	Upstairs.

## 9.—DECEMBER 3RD.

45	Fukagawa.	6.23 a.m.	feeble	2 seconds	Upstairs (Time doubtful).
3	Azabu .....	0.58 a.m.	sudden shock	very short	Downstairs.
	Kōjimachi.	0.58 a.m.	feeble	4 seconds	Upstairs machine indicated 2 mm.
	Chirikioku	0.57.16 p.		15 sec.	Very slight 15 mm.
	University Observatory .....				Earthquake recorded
7	Nagatacho.....	0.58	very slight		S.W. and N.E. very slight oscillation of lamps.
	Kobudai-gakko ...		.2 mm.		Felt upstairs very slight.

This shock, which was not felt in districts outside Tokio, is remarkable for the small area over which it was felt within the city itself, only being recorded at three neighbouring stations in Azabu. The record from Fukagawa is either a mistake or refers to another disturbance.

## 10.—DECEMBER 6TH.

55	Ushigome.	3.23 p.m.	sudden shock pretty strong	about 4 or 5s.	Downstairs.
123	Azabu .....	3.24 p.m.	feeble		
95	Minami Toshima..	3.26 p.m.	very feeble	1 sec.	Downstairs.
111	Kojimachi.	3.18 p.m.			
108	Azabu .....	3.24 p.m.	feeble	15 sec.	

EARTHQUAKE MOTION WITHIN A SMALL AREA. 59

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
3	Azabu .....	3.23 p.m.	feeble		Downstairs Longitude $139^{\circ} 44' 30''$ E. $35^{\circ} 39' 17''$ N.
45	Fukagawa.	1.49 a.m.	feeble		Downstairs.
45	Fukagawa.	4.31 a.m.	feeble		Downstairs.
54	Yotsuya ...	3.25	pretty strong	4 minutes	Downstairs.

108.—Azabu, at 3.24 p.m., quick, slight vibrations lasting 15 sec. The first shock was the most severe.

Kobudaigakko—Shock felt.

We have here an example of another shock only felt on the western part of Tokio, and although two observers report it as being pretty strong, it does not appear to have affected the instruments at the observatory in the centre of the city or those in the north-east.

11.—DECEMBER 7TH.

Hongo (Sekiya)..	at night	slight		
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12.—DECEMBER 8TH.

3	Azabu .....	8.2 p.m.	little tremor		Downstairs.
123	Azabu .....	8.2 p.m.	feeble		
108	Azabu .....	8 p.m.	feeble	4 or 5 sec.	
118	Azabu .....	8.8 p.m.	feeble	2 sec.	Ground floor.
5	Azabu .....	8.2 p.m.	very feeble	30 sec.	Ground floor.
4	Akasaka ..	8 p.m.	feeble	1 or 2 sec.	Downstairs.
4	Akasaka ..	8.2 p.m.	pretty strong	10 sec.	Downstairs.
19	Yotsuya ...	8 p.m.	feeble		Downstairs.
54	Yotsuya ...	7.40 p.m.	strong	1 minute	Downstairs.
54	Yotsuya ...	7.50 p.m.	strong	1m. 40sec.	Downstairs.
54	Yotsuya ...	9.15 p.m.	feeble	4 sec.	Downstairs.
90	Yebara ...	8.1 p.m.	pretty strong	about 1m.	Downstairs west-north to east-south.
55	Ushigome.	8 p.m.	pretty strong	5 sec.	Downstairs.
54	Yotsuya ...	7.30 p.m.	strong	1 minute	Downstairs.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
129	Kanda.....	8.2 p.m.	short tremor		Downstairs.
49	Ushigome.	8.1.49 p.m.	feeble	15 sec.	Downstairs.
49	Ushigome.	8.2.20 p.m.	pretty strong	38 sec.	Downstairs.
41	Minami-Katsushika .....	8.3 p.m.	feeble	30 sec.	Downstairs north-west.
100	Hongo .....	8 p.m.	feeble		Downstairs.
104	Kyobashi ..	8 p.m.	sharp shock		
123	Azabu .....	8.40 p.m.	feeble		
	Hongo (Sekiya) ..	8.02 p.			
	Hitotsubashi .....	8.02 p.			
	Chirikioku	8.02.00 p.	amp period	.4 .5 50 sec.	S.W.-N.E.

104.—Hongo, F. W. Strange. Although the observer was writing at a desk in a quiet room at 8 p.m. no shock was felt, neither did 10 other people in the house feel it. In Tsukiji it was quite sharp and also in Azabu.

132.—Hongo, Masagocho, at 8.3 p.m. a tremor lasting 25 sec. was felt while downstairs.

131.—Surugadai, Suzukicho, while upstairs moderate vibrations lasting 10 sec. were felt. Very small vibrations preceded for about 30 seconds the stronger movements. No jerk.

Kobudaigakko—Movement short and gentle.

122.—Takanawa, Chooji, at 5 p.m. a very slight trembling, lasting a few seconds. A minute later a more decided motion also lasting a few seconds.

110.—Shiba Kiridoshi, 8.2 p.m. a short, sharp jerk. Lamps moved.

This earthquake was only felt in the west and north parts of the city, being strongest in the western and north-western parts of this area.

The 8 p.m. shock was only felt at Asawa a few miles N.E. from Tokio.

EARTHQUAKE MOTION WITHIN A SMALL AREA. 61

13.—DECEMBER 11TH.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
	Hitotsu-bashi..... Chirikioku	9.55.47 9.55.47 p.			Very slight.

14 AND 15.—DECEMBER 14TH.

	Chirikioku	11.55.12 a.	amp .2 period 2.3	2m. 12s.	S.-N. It is clear that this was not felt on account of the long period. It is a good example of a slow earthquake.
		10.55.09 p.	amp .3 period .2	2m. 30s.	S.S.E.-N.N.W. It is clear that this was not felt on account of the long period. It is a good example of a slow earthquake.
	Hongo (Sekiya)..	11.55.12 a.			
	Hitotsu-bashi.....	11.55.12 a.			

The shock at 11.55.12 (or 12.40 at C.) according to the Chirikioku maps, was only felt at Kamakura.

16.—DECEMBER 16TH.

96	Minami-Toshima ...	8.30 a.m.	pretty strong		
59	Nihon-bashi.....	8.30 a.m.	pretty strong	about 1m.	Upstairs.
75	Asakusa ...	8.32 a.m.	pretty strong	5 seconds	Downstairs.
69	Koishi-kawa.....	8.30 a.m.	pretty strong		To north - east from south-west.
94	Kita-Toshima ...	8.30 a.m.	feeble	30 sec.	Downstairs.
45	Fukagawa.	8.28 a.m.	feeble	1 minute	Upstairs.
119	Kōjimachi, German Legation...	8.30 a.m.		30 sec.	Downstairs.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
116	Kōjima- chi, Bri- tish Lega- tion.....	8.30 a.m.	tremor and jerk		Downstairs.
13	Azabu .....	8.25 a.m.	pretty strong	1m. 10s.	Upstairs.
22	Shiba .....	8.39 a.m.	pretty strong	38 sec.	Downstairs (time is uncertain).
	Honjo .....	8.15 a.m.	pretty strong	2 sec.	Downstairs.
3	Azabu .....	8.28 a.m.	pretty strong		Downstairs.
31	Nihon- bashi .....	8.25 a.m.	pretty strong	30 sec.	Downstairs.
34	Kanda.....	8.35 a.m.	pretty strong	3m. 27s.	Downstairs.
53	Ushigome.	8.40 a.m.	pretty strong	2m.	Downstairs.
107	Shiba .....	8.20 a.m.	strong tremor		Glass doors ratt- led sharply.
129	Kanda.....	8.28 a.m.	long jerk		Upstairs and downstairs.
121	Shiba .....	8.31 a.m.	sharp shock		Downstairs.
76	Kyobashi..	8.34 a.m.	strong	1 minute	Upstairs, south from north.
83	Honjo .....	8.36 a.m.	strong	20 sec.	Downstairs.
14	Azabu .....	8.31 a.m.	strong	40 sec.	Downstairs.
111	Kōjimachi.	8.28 a.m.			
51	Yotsuya ...	8.35 a.m.	strong	5 second	Downstairs.
93	Shitaya ...	8.30 a.m.	feeble	1m. 5s.	Downstairs.
5	Kanda.....	8.28 a.m.	strong		Downstairs.
106	Kyobashi..	8.30 a.m.	tremor	20 sec.	Upstairs.
104	Hongo .....	8.30 a.m.	tremor	2 minutes	Duration deter- mined by motion of water in a vessel, and noise from windows.
54	Yotsuya ...	8.25 a.m.	strong	2 minutes	Downstairs.
67	Hongo .....	8.50 a.m.	strong	3 minutes	Downstairs.
125	Koishi- kawa .....	9.27 a.m.	strong and jerky	short	Upstairs.
59	Hongo ...	8.30 a.m.			
117	Nihon- bashi .....		strong jerk	30 sec.	Downstairs.
131	Surugadai.	8.30 a.m.	strong, no jerk		Upstairs.
123	Azabu .....	8.25 a.m.	strong		

EARTHQUAKE MOTION WITHIN A SMALL AREA. 63

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
47	Shiba .....	8.27 a.m.	strong	1 minute	Downstairs twice shook.
101	Shinagawa	8.30 a.m.	short and jerky tremor	10 sec.	Downstairs W.S. W. to E.N.E.
132	Hongo ...	8.32 a.m.	tremor	1 minute	Upstairs in brick building.
85	Minami Katsushika .....	8.30 a.m.	strong	2 sec.	Downstairs, from west-south (?)
107	Kojimachi.	8.25 a.m.	long and with a jerk		Downstairs.
46	Minami Katsushika .....	8.30 a.m.	strong	20 sec.	Downstairs.
10	Yotsuya ...	8.28 a.m.	strong	30 sec.	Downstairs.
54	Yotsuya ...	8.40 a.m.	strong	1m. 30s.	Downstairs from south-east (?)
11	Akasaka ..	8.30 a.m.	strong	15 sec.	Downstairs from E.E.N. (?)
36	Kanda ...	8.27 a.m.	strong	1 minute	Upstairs from E.
72	Kita Tushima..	8.28 a.m.	strong	2 minutes	Downstairs.
115	Tsukiji .....	8.35 a.m.	short, sudden, strong jerk		Downstairs.
4	Akasaka...	8.29 a.m.	strong	1 minute	Downstairs.
35	Honjo .....	8.34 a.m.	strong	2s. or 3s.	Downstairs.
55	Kōjimachi.	8.30 a.m.	strong	1 minute	Downstairs.
55	Kyobashi..	8.20 a.m.	strong	3 minutes	Downstairs from east-south (?)
90	Yotsuya ...	8.25 a.m.		1 minute	
12	Azabu .....	8.25 a.m.	feeble	30 sec.	Downstairs.
28	Fukagawa.	8.29 a.m.	strong	1 minute	Downstairs from west to east.
25	Akasaka...	8.28 a.m.	strong	1 minute	Downstairs.
41	Minami-Katsushika .....	8.30 a.m.	strong	1 minute	Downstairs from north.
114	Shiba .....	8.35 a.m.	strong	6s. or 7s.	
133	Kōjimachi, Nakani-bancho ...	8.27 a.m.	a long shock	4 sec.	Upstairs.
95	Minami-Toshima..	8.20 a.m.	strong	10 sec.	Downstairs from E.N.E. to W.S. S.
	Hongo,	8.29 a.m.		10 sec.	
	Sekiya ...	8.29 a.m.			

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
	Hitotsu- bashi.....	8.29 a.m.			
	Chirikioku	8.28.21 a.m.	amp 2.5 period 1.5	2 sec.	W.N.W. - E.S.E. vertical motion. amp. .3 period .4
	Yokohama	8.30 a.m.		10 sec.	N.W.-S.E.

Kojimachi, British Legation—In a brick bungalow downstairs at 8.29 a.m. there was a horizontal motion, slow and without jerks, commencing lightly and gradually increasing in intensity—the rapidity of oscillations increasing as the disturbance went on. Direction E.N.E. to W. by S. This shock was typical of shocks so often felt in Tokio.

129.—Surugadai, at 8.23 a.m. a severe shock—a long jerk. Bells rang. Felt upstairs and downstairs.

121.—Shiba, Sannai—A sharp short shock at 8.31 a.m.

110.—Shiba, Kiridoshi—At 8.25, a sharp shock as if from below, followed by long strong tremors.

117.—Iidamachi, Kojimachi, at 8.30 a.m. a heavy blustering shock. The noise was remarkable, sounding like the moving of furniture overhead.

122.—Takanawa, Chôoji, at 8.30 a.m. rather strong shock lasting 30 sec. No jerk, but the bells rang. Downstairs.

Koishikawa Riding School, a strong jerk.

118.—Azabu, 8.30 a.m. a long strong shake.

126.—The University, Hongo, 8.25 a.m., a short shake and then a longer one. Sensible for 30 sec.

106.—Tsukiji, No. 32, at 8.30 while upstairs a shock followed by a tremor lasting 20 or 30 sec.

109.—Tsukiji, French Legation, a shock tolerably strong and long. Felt upstairs.

This shock which was felt over a large area (2,260 square *ri*) although its period was fairly long, was felt throughout Tokio and apparently with equal intensity in different parts of



EARTHQUAKE MOTION WITHIN A SMALL AREA. 65

the city but by rather more observers on high ground. There were 8 waves in 10 seconds.

17, 18, AND 19.—DECEMBER 17TH.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
95	Asakusa ...	6.23 a.m.	feeble	3s.	Downstairs.
123	Azabu .....	0.15 a.m.	feeble		
130	Kyobashi..	6.32 a.m.	two short jerks	15 sec.	Upstairs.
94	Kita-Toshima..	5 a.m.	feeble		Downstairs.
3	Azabu .....	11.44 a.m.	pretty strong		Downstairs.
107	Shiba .....	6.20 a.m.	tremor		Downstairs.
12	Azabu .....	6.18 a.m.	feeble		Downstairs.
114	Shiba .....	6 a.m.	feeble	4s. or 5s.	
114	Shiba .....	11.30 p.m.			
125		6.17 a.m.	tremor	short	Upstairs.
72	Shitaya ...	0.17 a.m.	feeble	30s.	Downstairs.
111	Kōjimachi.	6.18 a.m.			
122	Shiba, Chooji.....	0.7 a.m.	jerk		Downstairs.
4	Akasaka...	0.17 a.m.	feeble		Downstairs, direction of north-south.
4	Akasaka...	6.17.30 a.m.	feeble	1s.	Downstairs, direction of north-south.
8	Shiba .....	0.19 a.m.	feeble	14s.	Upstairs, from east-south to north-west.
28	Fukagawa.	0.17 a.m.	feeble	7s. or 8s.	Downstairs.
31	Nihon-bashi .....	0.17 a.m.	feeble		Downstairs.
31	Nihon-bashi .....	6.16 a.m.	feeble		Downstairs.
3	Azabu .....	0.20 a.m.	feeble		Downstairs.
45	Fukagawa.	0.17 a.m.	feeble		Downstairs.
129	Kanda .....	0.19 a.m.			
129	Kanda .....	6.19 a.m.			
4	Akasaka ...	11.47 p.m.	jerk	about 20.	Downstairs.
121	Shiba .....	11.42 p.m.	short sharp shock	2s.	
	Kōjimachi.	0.20 a.m.		25s.	
		0.17 a.m.		1s.	
		6.15 a.m.	slight shock		
133	Kōjimachi.	0.10 a.m.	long shock	5s.	Upstairs.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
133	Kōjimachi.	11.45 p.m.	slight shock	4s.	Upstairs.
132	Hongo .....	11.47 p.m.	tremor		
95	Minami-Toshima..	11.38 p.m.	pretty strong	3s.	Downstairs.
75	Asakusa ...	11.40 p.m.	feeble	5s.	Downstairs.
111		11.30 p.m.	pretty feeble	4s. or 5s.	
132	Hongo .....	5.30 a.m.	jerk		
22	Shiba .....	11.50 p.m.	feeble	2s.	Downstairs.
72	Shitaya ....	11.43 p.m.	feeble	5s. or 6s.	Downstairs.
11	Azabu .....	0.5 a.m.	short, pretty strong		Downstairs.
31	Yotsuya ...	9.15 a.m.	long strong		Downstairs.
54	Kanda .....	9.30 a.m.	strong	long	Upstairs.
54	Kanda .....	12.15			
	Hongo	0.17.8 a.			
	(Sekiya)..				
	Hitotsu-	6.17.22 a.			
	bashi				
	(Sekiya)..				
	Chirikioku	0.17.08 a.		10s.	Slight.
	Chirikioku	6.17.22 a.			Very slight.
		11.41.14 p.	amp	.2	E.-W.
			period	.6	
	Yokohama	11.40.0 p.		8s.	N.W.-S.E.

95.—Yotsuya, at 11.38 a.m.

95.—Asakusa, at 11.45 p.m.

Kobudaigakko—At 12.20.0 a.m. slight shock.

Kobudaigakko—At 6.15 a.m. slight shock.

117.—Kojimachi, Iidamachi, 12.17.0 a.m. two sharp shocks felt in bed upstairs. They were felt by the servants downstairs, but not by a visitor.

Kojimachi, 7 Nagatacho—12.16.0 a.m. a sharp shock lasting 25 sec. Motion horizontal.

Kojimachi, English Legation—0.17.0 a.m. distinct earthquake tremor, direction E.W. Duration 1 or 2 sec.

108.—Azabu, 0.20.0 a.m. sharp decided shock, more of a jerk than a tremor, lasting 5 sec. downstairs.

115.—Tsukiji, American Legation, 12.10 night, a long shock

which seemed to come from below. Upstairs in a wooden building.

121.—Shiba, 11.42.0 p.m. short sharp shock preceded for 2 sec. by a deep rumbling sound.

121.—Shiba, 0.18.0 a.m. short sharp shock like the previous shock.

109.—Tsukiji, French Legation, 12.20 a.m. a light short shock.

109.—Tsukiji, French Legation, 11.40 p.m. very feeble shock.

118.—Azabu, 11.45 p.m. a sharp shock with tremor.

132.—Masagocho, Hongo, 11.47 p.m. last night a sharp jerk followed by a tremor.

Masagocho, Hongo—6.20 a.m. a tremor and jerk.

129.—Surugadai, 12.19 a.m. slight shock.

Surugadai—6.19 a.m. slight shock.

The 0.17.08 a.m. disturbance, although felt over 720 square *ri*, in Tokio was with but three exceptions only felt in the western and northern part of the city, or from Takanawa (Shiba) on the south to Koishikawa in the north. At three places it was short and sharp as if from below.

The 6.17.22 a.m. shock was in Tokio practically felt over the very same area as the 0.17.08 a.m. disturbance. It also extended over a large area. At three places it was felt as a jerk.

The 11.41.14 p.m. disturbance did not extend over a large area, but was only felt in Tokio, and this with but one exception at places along a north and south line like the 0.17.08 a.m. shock. In Shiba it was sharp and preceded by a noise.

## 20.—DECEMBER 19.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
	Komagome .....	11 p.m.	feeble		Doubtful.
	Hitotsu-bashi .....	6.0.12			
	Chirikioku	6.00.20 p.	very slight		

According to maps this shock was only felt in Tokio.

## 21.—DECEMBER 21ST.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
4	Nagatacho	2.8 p.m.	feeble		
	Akasaka...	2.6 p.m.	feeble		
	Kokadai-gaku .....	2.7 p.m.	very slight		
	Hongo (Sekiya)..	2.5.55 p.			
	Hitotsu-bashi (Sekiya)..	2.5.55 p.			
	Chirikioku	2.05.55	very slight		

This shock which was only felt in Tokio, with the exception of observations at observatories was only felt at two places on the west side of the city.

## 22.—DECEMBER 22ND.

	Fukagawa.	1.19 p.m.	feeble	1s.	Upstairs.
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## 23 AND 24.—DECEMBER 24TH.

45	Fukagawa.	5.6 a.m.	feeble	1s.	Upstairs, doubtful shock.
	Fukagawa.	12.3 a.m.			
	Hitotsu-bashi .....	7.51.30 a.			
	Chirikioku	4.09.41 a.			Very slight. S.W.-N.E. a slow earthquake, and therefore not felt.
Chirikioku	7.51.38 a.	amp. .12 period 2	about 1m.		

This 4.09.41 shock extended over 272 square *ri*.

## 25.—DECEMBER 31ST.

	Chirikioku	1.24.45 a.			Very slight.
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This shock was only felt in Tokio.

## 26.—JANUARY 1ST.

126	Hongo ...	3.25	jerk	1sec.	Very slight.
	Chirikioku	3.31.38 p.	very slight		

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This shock was only felt at the observatories in Tokio. It extended over 1,460 square *ri*.

27.—JANUARY 9TH.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
45	Fukagawa.	1.41 a.m.	feeble		Upstairs.

28.—JANUARY 11TH.

55	Ushigome.	8.53 a.m.	feeble	25. or 3s.	Downstairs.
116	Kōjimachi.	8.42 a.m.	feeble		
		8.50 a.m.	slight tremor		
125	Hongo .....	8.50 a.m.	series of shocks	50s.	
130	Kyobashi..	8.54 a.m.	slight	2s.	Downstairs.
13	Azabu .....	8.52 a.m.	feeble	1m. 15s.	
111	Kōjimachi.	8.51 a.m.			
108	Azabu .....	8.49 a.m.	pretty strong	1m. 40s.	Downstairs.
4	Akasaka, Aoyama..	8.50 a.m.	feeble		On the road.
109	Kyobashi, Tsukiji ...	8.50 a.m.	tremor		Upstairs.
3	Azabu .....	8.50 a.m.	pretty strong		Shortshock downstairs.
110	Shiba, Kiridoshi.	8.55 a.m.	tremor		
114	Shiba .....	4.18 a.m.	short		Downstairs.
85	Myogadani .....				Not felt.
	Nagatacho, Kōjimachi .....	8.42	slight		Felt as two small shocks, stronger in Azabu.
	Hongo (Sekiya)..	8.50.30			
	Hitotsubashi .....	8.50.30			
	Chirikioku	8.50.36 a.	amp .4 period 1.8	1m.	E.S.E. - W.N.W. Rather long period to have been so well felt.
	Yokohama	3.25.0 p.m.			N.E.-S.W.
	Yokohama	8.55.0 a.			N.E.-S.W.

This disturbance which extended over a large area (1,480 square *ri*), was in Tokio practically only felt along a N. and S.

line extending from Shiba through Kojimachi, that is to say in the west side of the city.

Its period was moderately long. There were 7.5 waves in 10 seconds.

## 29.—JANUARY 14TH.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
87	Honjo .....	8.15 a.m.	feeble	short	Downstairs (?)
116	Kōjimachi.	5.30 p.m.	slight	short	
55	Ushigome.	5.30 p.m.	feeble	5s.	Downstairs.
5	Kyobashi..	5.33 p.m.	feeble	5s.	Downstairs.
5	Azabu .....	5.36 p.m.	feeble		
45	Fukagawa.	5.29 p.m.	feeble	2m.	Upstairs.
113	Surugadai.	5.40 p.m.	feeble		Downstairs.
	Nagata- cho, Kōji- machi .....	5.32 p.m.	tremor		Preceded by very slight tremors.
	Chirikioku	5.31.55 p.	slight	15 sec.	E.W. slight ver- tical motion.

This shock which was only felt in Tokio, was only observed by one or two observers living on the N.W. side of the city.

## 30.—JANUARY 15TH.

4	Akasaka ...	6.13.0(?)p.	feeble		
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This shock was felt for some distance along the coast of Kadzusa.

## 31.—JANUARY 16TH.

4	Akasaka ...	3.35 a.m.	feeble	5s. or 6s.	
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## 32.—JANUARY 27TH.

3	Azabu .....	10.4 a.m.	feeble	short	Downstairs.
	Hitosu- bashi .....	10.7.0 a.			
	Chirikioku	10.05.33 p.	very slight	about 10s.	N.-S.

This shock was felt over 180 square *ri*.

EARTHQUAKE MOTION WITHIN A SMALL AREA. 71

33, 34, 35, AND 36.—FEBRUARY 2ND.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
133	Kojimachi.	1.20 p.m.	strong	long about 3m.	
133	Kojimachi.	2.28 p.m.	strong		
133	Kojimachi.	3.5 p.m.	feeble		
133	Kojimachi.	4.47 p.m.	strong	quick	
62	Asakusa ...	1.15 p.m.	feeble	20s.	Downstairs.
126	Hongo .....	3.42 p.m.	pretty strong	1m.	
96	Ushigome.	1.30 p.m.	feeble		
96	Ushigome.	3.45 p.m.	pretty strong		
132	Hongo .....	1.20 p.m.	strong	long	Upstairs.
132		3.45 p.m.	feeble		Upstairs.
18	Shiba .....	1.17 p.m.	strong	1m.	Downstairs.
11	Azabu .....	1.20 p.m.	strong	3m.	Downstairs.
11	Azabu .....	3.45 p.m.	feeble	3s.	Downstairs.
55	Ushigome.	1.20 p.m.	strong	3m.	Downstairs.
116	Kojimachi.	3.45 p.m.	strong		
46	Honjo .....	0.16	strong	1m. 20s.	Downstairs.
42	Kojimachi.	1.15 p.m.	strong	1m. or 2m.	Upstairs south to north.
122	Kojimachi.	3.45 •	strong	1m.	Shoji rattled for 1m. Preceded by a rumbling sound. No jerk.
111	Kojimachi.	3.4 p.m.			
90	Yotsuya ...	1.18 p.m.	strong	3m.	Shocked from N.
90	Yotsuya ...	3.43 p.m.	feeble	1m.	Shocked from N.
116	Kojimachi.	1.15 p.m.	tremor	20s.	Downstairs.
5	Shiba .....	1.16 p.m.		40s.	Downstairs.
122	Chooji, Shiba .....	1.15 p.m.	strong	long	Commenced gently.
130	Shiba .....	1.25 p.m.	jerk	8s.	Downstairs.
108	Azabu .....	3.41 p.m.	sharp shock	30s. to 1m.	Motion quicker than at 1.15 p. downstairs.
108	Azabu .....	1.15 p.m.	feeble	1m.	Downstairs.
32	Nihon- bashi .....	1.35 p.m.	strong	2m.	Upstairs.
129	Kanda .....	3.40 p.m.	tremor	long	Downstairs.
130	Shiba .....	3.50 p.m.	jerk	3s.	Downstairs.
106	Kyobashi..	1.40 p.m.	feeble	1m.	Downstairs.
106	Kyobashi..	4.4 p.m.	tremor	30s.	Downstairs.
45	Fukagawa.	0.16 p.m.		3m.	Upstairs.
40	Fukagawa.	1.15 p.m.	strong	40s.	Downstairs.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
40	Fukagawa.	3.35 p.m.	feeble	7s. or 8s.	Downstairs.
108	Azabu .....	1.16 p.m.	strong	3m.	Downstairs.
28	Fukagawa.	1.25 p.m.	strong	2m.	Downstairs.
52	Shitaya.....	1.30 p.m.	strong	25s.	Upstairs.
110	Kiridoshi, Shiba .....	1.18 p.m.	hard tremor	long	Lamps swinging.
111	Kojimachi.	1.15 p.m.			
120	Shiba .....	1.15 p.m.	strong	long	Easy motion, did not rattle glass.
	Honjo .....	1.23 p.m.	strong	1m.	Downstairs.
115	Tsukiji .....	1.15 p.m.	strong	1m.	Motion easy, downstairs.
114	Shiba .....	1.15 p.m.	strong severe	long	Horizontal motion.
129	Kanda .....	1.17 p.m.	tremor	long	Downstairs.
72	Shitaya.....	1.25 p.m.	strong	long	Upstairs.
45	Fukagawa.	3.45 p.m.		1m.	Upstairs.
31	Kyobashi..	1.45 p.m.	strong	3m.	Downstairs.
126	Hongo .....	1.11 p.m.		long 40s.	Gentle oscillation.
	Nagatacho	1.15 p.m.	moderate		Lamps described ellipse NE.-SW.
		3.40 p.m.	moderate		Lamps did not swing, but wobbled; apparently vertical. Not so strong as 1.15 shock.
	Hongo (Sekiya)..	{ 1.15.15 p. 2.24.0 p.			
	Hitotsu- bashi .....	{ 1.15.15 p. 2.24.0 p.			
	Chirikioku	1.15.15 p.	amp 3.0 period 3.7	3.48	W.N.W. - E.S.E. Vertical motion amp. .5.
		2.23.46 p.	.7 1.4	1.49	E.W.
		3.00.14 p.	very slight		
		3.41.27 p.	3.8 2.4	4.05	W.S.W. - E.N.E.
	Yokohama	1.16.0 a.		8 sec.	E.W.
		3.45.0 p.			

The 1.15.15 p. shock shook 3,440 square *ri*. There were 5 waves in 10 seconds.

The 2.23.46 p. shock shook 1,680 square *ri*. There were 7 waves in 10 seconds.



EARTHQUAKE MOTION WITHIN A SMALL AREA. 73

The 3.00.14 p. shock shook 730 square *ri*.

The 3.41.27 p. shock shook 2,630 square *ri*. There were 4.5 waves in 10 seconds.

37.—FEBRUARY 3RD.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
I14	Shiba .....	3.15 p.m.	feeble	7s. or 8s.	
I11	Kōjimachi.	2.35 p.m.			
I12	Shiba .....	2.36 p.m.	tremor	3s. or 4s.	Upstairs.
108	Azabu .....	2.40 p.m.	slight jerks	3s. each	Two slight shock with an interval of a minute.
I33	Kōjimachi.	2.37 p.m.	strong		
I32	Hongo.....	1.35 p.m.	feeble		Upstairs.
	Nagata-cho, Kōjimachi .....	2.35.0	slight	short	Sudden and preceded by a short noise.
	Hongo (Sekiya)..	2.37.20			

38.—FEBRUARY 5TH.

4	Akasaka ..	1.15 p.m.	strong	long	Downstairs.
4	Akasaka ..	3.41 p.m.	strong	long	Downstairs.
I33	Kōjimachi.	1.5 p.m.		1m.	
I12	Shiba .....	0.53 p.m.	jerk	short	Upstairs. S.W. N.E.
55	Ushigome.	pretty (?) before 1 p.	feeble	6s. or 7s.	Downstairs.
4	Akasaka ..	0.50 a.m.	feeble		Downstairs.
I16	Kōjimachi.	0.30 a.m.	tremor	short	
I20	Shiba .....	7 a.m.			North to south.
	Nagata-cho, Kōjimachi .....	0.52 a.m.	gentle		
	Hongo (Sekiya)..	0.50.56 a.			
	Hitotsu-bashi.....	0.50.56 a.			
	Chirikioku	0.50.56 a.	amp 1.6	about 1m.	S.W.-N.E.
	Yokohama	0.53.0 a.	period 2.1		

This shock disturbed a large area (9,670 square *ri*). There were 7 waves in 10 seconds.

## 39.—FEBRUARY 7TH.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
72	Shitaya.....	4.36 p.m.	tremor	short 15s.	Downstairs.

A shock was felt at this time in Nambu, North Japan.

## 40 AND 41.—FEBRUARY 10TH.

96	Ushigome.	3.20 p.m.	strong		
96	Ushigome.	6.30 p.m.	strong		
		6.40 p.m.	tremor	3-8s.	
111	Kōjimachi.	3.26 p.m.			
108	Azabu.....	3.30 p.m.	slight	30s.	Motion slow, downstairs.
134	Kōjimachi.	3.27 p.m.	slight	30s.	Upstairs. A jerk followed by a tremor.
108	Azabu.....	6.40 p.m.	strong	3m.	Downstairs.
111	Kōjimachi.	6.37 p.m.			
11	Azabu.....	4 p.m.		long	Downstairs.
11	Azabu.....	6.40 p.m.	feeble	short	Downstairs.
119	Kōjimachi.	6.42 p.m.	tremor	4s.	Downstairs.
32	Nihon- bashi.....	6.40 p.m.	feeble	1m.	Upstairs.
134	Kōjimachi.	6.39 p.m.	tremor	short	Upstairs.
125	Koishi- kawa.....	6.40 p.m.	gentle		Upstairs, a single shock.
116	Kōjimachi.	6.40 p.m.	jerk	long	Followed by tre- mors, downstairs.
114	Shiba.....	3.30 p.m.	feeble	3s. or 4s.	
114	Shiba.....	6.45 p.m.			
55	Ushigome.	3.25 p.m.	strong	1m.	Downstairs.
55	Ushigome.	6.45 p.m.	strong	6s. or 7s.	Downstairs.
41	Honjo.....	3.32 p.m.			
41	Honjo.....	6.46 p.m.	tremor	short	
4	Akasaka...	3.8 p.m.	feeble		Downstairs.
4	Akasaka...	6.38 p.m.	jerk	40s.	Downstairs.
126	Hongo.....	3.30 p.m.	sharp		
126	Hongo.....	6.15 p.m.	pretty sharp		Not so strong as 3.30 p.m. shock.
76	Asakusa...	6.38 p.m.	feeble	5s.	Upstairs.
45	Fukagawa.	3.30 p.m.			Upstairs.
45	Fukagawa.	6.23 p.m.			Upstairs.
132	Hongo.....	3.30 p.m.	feeble		Upstairs.
132		6.45 p.m.	strong		Upstairs.
	Shiba.....	3 p.m.	severe		
	Shiba.....	4 p.m.	severe		

EARTHQUAKE MOTION WITHIN A SMALL AREA. 75

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
133	Kōjimachi.	6.40 p.m.	strong	long	Downstairs.  Preceded by a tremor.  N.E.-S.W. E.-W.
18	Kōjimachi.	6.36 p.m.	strong	30s.	
	Kobu-daigakko	3.25			
	Kobu-daigakko.	6.40			
	Nagatacho, Kōjimachi .....	6.40	short		
	Hongo (Sekiya)..	{ 3.26.55			
	Hitotsu-bashi.....	{ 6.38.7			
	Chirikioku	3.26.55 p.	very slight	10 sec.	
	Yokohama	6.38.07 p.	very slight	12 sec.	
		3.34.0 p.			
		6.32.0 p.			

The 3.26.55 p. shock shook 160 square *ri*.

The 6.38.07 p. shock shook 880 square *ri*,

42.—FEBRUARY 11TH.

III	Kōjimachi.	3.40 p.m.			
4	Akasaka...	2.41 p.m.	feeble		
	Hongo (Sekiya)..	3.38.56 p.			
	Hitotsu-bashi.....	3.38.56 p.			
	Chirikjoku	3.38.56 p.	very slight		

Only felt in Tokio.

43.—FEBRUARY 12TH.

III		11.35 a.m.			Probably a mistake for Feb. 13th.
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44.—FEBRUARY 13TH.

122	Chooji, Takawana...	11.30 a.m.	jerk		
96	Minami-Toshima..	11.25 a.m.	feeble		
III	Kōjimachi.	11.35 a.m.			

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
	Hongo (Sekiya)..	11.33.44 a.			
	Hitotsu- bashi.....	11.33.44 a.			
	Chirikioku	11.33.44 a.	slight	25 sec.	S.-N.

Only felt in Tokio.

45.—FEBRUARY 15TH.

104	Hongo.....	3.20 p.m.	short jerk		
	Hongo (Sekiya)..	3.20.30 p.			
	Chirikioku	3.43.38 p.	very slight	30 sec.	E.-W.

It shook 460 square *ri* (?)

46.—FEBRUARY 17TH.

111	Kojimachi.	12.40 p.m.			
	Chirikioku	0.16.17 p.	very slight	50 sec.	E.-W.

This shock was felt in Tokio and to the N.E. in Sakura and Narita. It shook 170 square *ri*.

47.—FEBRUARY 18TH.

45	Shiba .....	6.45 p.m.	feeble	2m.	Downstairs.
41	Honjo .....	6.22 p.m.	feeble		
	Chirikioku	6.13.45 p.	very slight	15 sec.	E.-W.

This shock was felt in Tokio and to the North and East in Mohara, Sakura, Sakai, Asaw (?), and Mito, shaking 570 square *ri*.

48.—FEBRUARY 22ND.

	Kobu- daigakko.	10.25.0.	slight		
	Nagata- cho, Kōji- machi .....	10.27 a.m.	very slight		
	Shinbashi..	11.10	slight tremor		
	Chirikioku	10.24.43 a.	.7 3.2	1.30	E.-W. slow earth- quake.
	Hongo (Sekiya)..	10.25.0			
	Hitotsu- bashi.....	10.25.0			

EARTHQUAKE MOTION WITHIN A SMALL AREA. 77

This shock was felt in Tokio and all down the coast from Kamaishi a distance of over 200 miles. Shaking 5,220 square *ri*. There were 4 waves in 10 seconds.

49.—FEBRUARY 23RD.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
	Chirikioku	11.10.50 p.	very slight	10 sec.	S.-N.

This shock was only felt in Tokio.

50.—FEBRUARY 24TH.

134	Kōjimachi.	2.7 a.m.	slight	1 sec.	Upstairs.
	Chirikioku	2.07.06 a.	very slight		E.-W.
	Hongo (Sekiya)..	2.26.0 a.			
	Hitotsu- bashi (Sekiya)..	2.26.0 a.			

It shook 580 square *ri*.

51 AND 52.—MARCH 1ST.

5	Shiba .....	9 50 p.m.	feeble	5s.	Upstairs.
	Hongo.....	9 a.m.	feeble		
	Nagata- cho, Kōji- machi .....	3 30	feeble		
60	Hongo.....	9 59 p.m.	jerk	short 2s.	Downstairs.
11	Azabu.....	10 5 p.m.	strong	20s.	Downstairs.
126	Hongo.....	9 54 p.m.	feeble	10s.	
45	Fukagawa.	9 55 p.m.	feeble		Upstairs.
87	Honjo .....	9 45 p.m.	feeble	short 3s.	Downstairs.
117	Kōjimachi.	9 50 p.m.	slight	short	Upstairs.
68	Koishi- kawa .....	9 55 p.m.		3s.	Downstairs.
31	Nihon- bashi .....	9 55 p.m.	strong	short	Downstairs.
134	Kōjimachi.	9 57 p.m.	jerk and tremor		Preliminary tre- mor upstairs.
119	Kōjimachi.	10 p.m.	tremor	4s.	Downstairs.
133	Kōjimachi	9 52 p.m.		long	
122	Chōōji, Shiba.....	10 p.m.	jerk		
122	Chooji, Shiba.....	3 30 p.m.	slight tremor		
110	Shiba .....	10.4 p.m.	tremor		

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
	Hongo (Sekiya) ..	3.30.0 p.			
	Hitotsu-bashi .....	3.30.0 p.			
	Chirikioku	3.30.15 p.	slight	1.15	W.S.W.-E.N.E.
	Yokohama	9.54.12 p.	slight	30 sec.	S.-N.
		10.30.0 p.			

The shock at 9 p.m. was only felt in Tokio. The 3.30 shock was felt in Tokio and to the North and North-West at Ashikaga, Sakai, and Mito. The 10.30 shock was felt at Tokio, Ashikaga, Sakai, Mito, and Sakura.

The 3.30 p. shock shook 580 square *ri*, and the 9.54 p. shock shook 670 square *ri*.

## 53 AND 54.—MARCH 9TH.

	Nagata-cho, Kojimachi .....	5 a.m.	pretty strong	2s.	Preliminary tremors.
133	Kōjimachi.	5 a.m.	strong		
133	Kōjimachi.	10.20 p.m.	feeble		
134	Kōjimachi.	10.18 p.m.	feeble		Upstairs.
117	Ushigome.	4.50 a.m.	sharp	short	Upstairs, also felt downstairs.
125	Koishikawa .....	4.57 a.m.	sharp	continuous	Upstairs.
90	Yebara .....	4.54 a.m.	strong	20s.	
132	Hongo .....	5 a.m.			Upstairs.
7	Akasaka .....	4.58 a.m.	strong	about 1m.	Downstairs.
31	Nihon-bashi .....	4.55 a.m.	strong	short	Downstairs.
94	Kita-Toshima ..	5 a.m.	strong	4m.	Downstairs.
118	Azabu .....	4.56 a.m.	jerk	15 sec.	Two shocks in succession and sound of an explosion, ground floor.
22	Shiba .....	4.50 a.m.	strong	short 3s.	Downstairs.
110	Shiba .....	4.56 a.m.	jerk		As if the house was lifted.
121	Shiba .....	4.57 a.m.	sharp	2m.	Preceded by a loud rushing sound up and downstairs.

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No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
55	Ushigome.	4.58 a.m.	strong	2m.	Downstairs.
108	Azabu .....	4.49 a.m.	strong	2m.	
129	Kanda, Su- rugadai...	4.53 a.m.	two jerks	short	Downstairs.
119	Kojimachi.	5 a.m.	tremor	30s.	Downstairs.
122	Chooji, Shiba .....	5 a.m.	tremor		A rumble like ar- tillery wagons, a great hump and several shakes.
127	Kyobashi..	4.55 a.m.	sharp jerk		Upstairs, preced- ed by a heavy report like an explosion.
134	Kojimachi.	4.57 a.m.	sharp	short	Upstairs.
116	Kojimachi.	5 a.m.	sharp		Preceded by a noise.
114	Shiba .....	5 a.m.	strong	5s. or 6s.	
	Hongo (Sekiya)..	4.56.26 a.			
	Hitotsu- bashi .....	{ 4.56.26 a. 10.17.0p.			
	Chirikioku	4.54.16 a.	amp .4 period .2	25 sec.	N.N.W.-S.S.E.
	Chirikioku	10.7.1 p.	very slight		
	Yokohama	4.58.0 a.			S.E.-N.W. slight.

The 5 a.m. and the 10.7 p.m. shocks extended over a large area.

The 10 p.m. shock probably not felt in Tokio on account of its being slow period, Tokio being on the outer edge of the disturbance.

The 4.54.16 a. shock shook 620 square *ri*. The 10.17.01 p. shock shook 1,470 square *ri*.

55 AND 56.—MARCH 16TH.

	Nagata- cho, Koji- machi .....	6 a.m.			
	Nagata- cho, Kōji- machi .....	6.45 a.m.			
96	Minami- Toshima..	6.40 a.m.	feeble		Downstairs.

NO.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
110	Kiridoshi, Shiba .....	6 a.m.	tremor	long	
110		6.45 a.m.	strong	long	
31	Nihon- bashi .....	6.40 a.m.	tremor	short	Downstairs.
35	Honjo .....	5.58 a.m.	feeble	short 2s.	Downstairs.
47	Shiba .....	6.45 a.m.	feeble	2m.	Downstairs.
118	Azabu .....	5.58 a.m.	jerk	short	
118	Azabu .....	6.46 a.m.	strong		
117	Ushigome.	5.55 a.m.	slight	long	
117	Ushigome.	6.43 a.m.	strong		
87	Honjo .....	5.57 a.m.	strong	short	Downstairs.
87	Honjo .....	6.45 a.m.	feeble	short	Downstairs.
119	Kōjimachi.	4 a.m.	slight	short	Downstairs.
119	Kōjimachi.	6.45 a.m.	tremor	10 sec.	Downstairs.
127	Kyobashi..	6.44 a.m.	jerk	8 sec.	Upstairs, sharp shock.
125	Koishi- kawa .....	6.45 a.m.	strong tremor		Upstairs.
	Surugadai.	5.58.0 a.			Second shock not felt on Suruga- dai.
134	Kōjimachi.	5.58.0 a.	smart jerk		
134	Kōjimachi.	6.45 a.	gentle		
132	Hongo ...	6.0.0 a.			
132	Hongo ...	6.45 a.			
	Hongo (Sekiya)..	5.58.2 a.			
	Hitotsu- bashi .....	5.58.2 a.			
	Chirikioku	5.58.02 a.	amp .2 period .8	30 sec.	S.E.-N.W.
	Chirikioku	6.43.32 a.	amp .4 period .8	2.50	S.E.-N.W.
	Yokohama	6.0.0 a.			E.-W.
	Yokohama	7.0.0 a.			S.W.-N.E.

The 5.58.02 a. shock shook 1,990 square *ri*, and the 6.43.32 a. shock also shook 1,990 square *ri*.

17.—MARCH 17TH.

87	Honjo .....	7.55 p.m.	feeble	short	Downstairs.
41	Honjo .....	6.45 a.m.	feeble		North-South.
41	Honjo .....	8 p.m.	feeble	30 sec.	W.S.W. to E.N. E.



EARTHQUAKE MOTION WITHIN A SMALL AREA. 81

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
	Chirikioku Yokohama	7.55.36 p. 7.0.0 p.	very slight		S.E.-N.W.

This shock only felt in Tokio.

58.—APRIL 1ST.

	Chirikioku	6.17.08 a.	very slight		.
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59.—APRIL 3RD.

17	Kanda.....	8.24 p.m.		3m.	Upstairs.
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60.—APRIL 5TH.

11	Azabu .....	2.50 p.m.	strong	long	Downstairs.
73	Osatogori..	2.30 p.m.	strong	2m.	Downstairs.
114	Shiba .....	2.27 p.m.	strong	1m.	
112	Shiba .....	2.31 p.m.	jerk	3 or 4 sec.	Upstairs, severe tremors.
109	Kōjimachi.	2.30 p.m.	tremor	long	
55	Ushigome.	2.30 p.m.	strong	1m. 20sec.	Upstairs.
118	Azabu .....	3.35 p.m.	tremor	long	A jerk in the middle.
75	Asakusa ...	2.32 p.m.	strong	1ms. 10s.	Upstairs.
31	Nihon- bashi .....	2.32 p.m.	strong	long	Downstairs.
17	Nihon- bashi .....	2.28 p.m.	strong	2m.	Downstairs.
93	Kita- Toshima..	2.37 p.m.	strong	6 sec.	Downstairs.
76	Kyobashi..	2.35 p.m.	strong	2m.	Downstairs.
110	Shiba .....	2.31 p.m.	tremor	long	Severe.
119	Kōjimachi.	2.30 p.m.	tremor	1m.	
56	Fukagawa.	2.27 p.m.	very strong	1m.	Downstairs.
108	Azabu .....	2.34 p.m.	strong	1m. 30s.	Downstairs, severe, vibrations short and sharp.
28	Fukagawa.	2.34 p.m.	strong	2m.	Downstairs.
90	Yebara .....	2.28 p.m.	strong	1m.	
126	Honjo .....	2.30 p.m.	strong	long	
10	Hongo .....	2.30.10 p.	strong	1m. 30s.	
10	Kōjimachi.	2.30.10 p.	strong	2m. 20s.	

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
	Hitotsu-bashi.....	2.30.29 p.			
	Hongo ...	2.30.29 p.	period .7 amp 1.2	1.30	Vertical motion slight.
	Chirikioku	2.30.29 p.	period 1.2 amp .7	2m.	S.E.-N.W. Vertical motion amp. .5 period .2
	Hitotsu-bashi.....	.	period .9 amp .2	2.20	Vertical motion .5

This shock extended over 4,060 square *ri*. There were 14 waves in 10 seconds.

## 61.—APRIL 8TH.

	Chirikioku	2.22.32 p.	very slight		
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## 62.—APRIL 11TH.

	Chirikioku.	11.06.43 p.	very slight		
	Yokohama	2.30.0 p.			S.E.-N.W.

## 63.—APRIL 14TH.

134	Kōjimachi.	11.17.0 p.	slight	short	Upstairs.
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This shock only felt in Tokio.

No. 134 being a particularly careful observer, there is good reason for believing that at this time there was really a shock.

## 64.—APRIL 26TH.

96	Minami Toshima..	2.22 p.m.	feeble		Downstairs.
	Hitotsu-bashi.....	2.10.30 p.			

EARTHQUAKE MOTION WITHIN A SMALL AREA. 83

65.—APRIL 27TH.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
	Chirikioku	8.34.34 a.	amp .2 period 1.5	2m.	S.W.-N.E. Slow earthquake.

This shock shook 660 square *ri*.

66.—APRIL 29TH.

90	Yebara ....	10.25 a.m.	strong	3m.	Downstairs. Upstairs. Noise heard before the earthquake; heavy shock as if from an explosion.
75	Asakusa ...	9.57 a.m.	strong	2m.	
5	Shiba .....	10 a.m.	strong	40 sec.	
118		10 a.m.	tremor and jerk		
94	Kita-Toshima..	10 a.m.	strong	2m.	
129	Surugadai.	10.0 a.m.	severe jerks	long	Downstairs.
100	Hongo.....	10 a.m.	strong	long	Downstairs.
56	Honjo .....	9.57 p.m.	strong	long 2m.	Upstairs.
	Kyobashi..	10.4 a.m.			
121	Shiba .....	10.2 a.m.	sharp	long	Water in pond agitated. Trees swaying.
114		10 a.m.	strong	3 or 4m.	Downstairs.
28	Fukagawa.	10.2 a.m.	strong	2m.	
31		10.2 a.m.	strong	1m.	Upstairs.
109	Kōjimachi.	10 a.m.	strong	long	
	Hongo.....	10.0.33 a.			
	Hitotsu-bashi .....	10.0.33 a.			
	Chirikioku	10.0.33 a.	amp 5.6 period .8	8.0	S.E.-N.W. Vertical motion amp. 1.5. period .6
	Yokohama	10.03.0 a.			S.W.-N.E. Strong and long.
	Kanagawa	10.0.0 a.	amp. 6mm.		

This shock shook 5,080 square *ri*. There were 13 waves in 10 seconds.

## 67.—APRIL 30TH.

No.	LOCALITY.	TIME.	INTENSITY.	DURATION.	REMARKS.
	Chirikioku	5.44.38 a.	very slight		E.-W.

This shock shook 1,110 square *ri*.

## 68.—MAY 5TH.

	Chirikioku	8.52.24 p.	very slight		
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## 69.—MAY 6TH.

104	Hongo				
	(Strange)	2.54 p.m.	jerk	short	
104		2.59 p.m.	jerk	short	
104		3 p.m.	jerk	short	

## ANALYSIS OF RECORDS.

Altogether I distributed 2,010 post cards. Out of these between November 15th, 1887, and May 5th, 1888, a period of nearly 6 months, 103 observers sent in 496 records. Thirty-one observers, 14 of whom lived on the high ground and 17 lived on the low ground, although it seems impossible that they should not have felt at least one of the 69 shocks recorded, did not return a single card.

The balance of unused cards amongst actual observers up to May 5th was 1,064. Many of these since that date have been returned, but they have not been used in the following investigations, inasmuch as other observers had by May 5th exhausted the stock of cards with which they were provided.

The 496 records were made as follows:—370 came from 61 observers living on high ground, that is upon the western and northern side of Tokio, while 126 records came from 42 observers living on the low ground.

The average number of records per observer on the high ground was 6, while upon the low ground the average was 3.

The greatest number of observations was made at station number 4 upon the west side of Tokio, where by placing the record of several earthquakes upon one card, fifteen cards contained the record of 21 shocks.

On map No. 1 the hilly, high ground is indicated by shading and the stations by numbers. The short horizontal strokes give the number of observations made at the station to which they are contiguous. Stations with a circle round them are the non-observers.

This map clearly shows that the greatest number of earthquakes was observed by residents on the high ground.

The disturbances which were only felt in Tokio were at least 25 in number. In 8 other cases, as the shock was only recorded by one observer, it is possible that a mistake may have been made in observation. Such observations are accompanied with a note of interrogation.

The numbers of these earthquakes are, 4, 5?, 6?, 8, 9, 10, 11, 13, 14, 15, 20, 21, 22?, 24, 25, 27?, 29, 31?, 37, 39?, 42, 43?, 44, 49, 57, 58 59?, 61, 62, 63, 64, 68, 69.

Disturbances which were only felt at an observatory are in *italics*. All these earthquakes, with the exception of No. 57, which is said to have been felt upon the east side of the city, were only felt upon the hilly, hard ground upon the western and north-western side of the city. They are shown in map No. 2.

The disturbances which were felt in Tokio and which in addition also shook a large tract of country surrounding the city, in some cases the whole coast line for at least 200 miles, were 36 in number.

The numbers of these disturbances are 1, 2, 3 7, 12, 17, 16, 18, 19, 23, 26, 28, 30, 32 33, 34, 35, 36, 38, 40, 41, 45 46, 47, 48, 50, 51, 52, 53, 54, 55, 56, 60, 65, 66, 67.

From this it appears that about 41 per cent. of the shocks felt in Tokio are of local origin.

The 30 shocks which were felt in Tokio, and which shook a large tract of country may be subdivided as follows :—

1. Shocks which were felt all over Tokio. These are 6 in number, namely, numbers 2, 16, 19, 33, 60 and 66.

2. Shocks which practically were only felt upon the hilly, hard ground upon the west side of Tokio. These are 30 in number, namely, numbers 1, 3, 7, 12, 17, 18, 28, 30, 32, 34, 35, 36, 38, 40, 41, 46, 48, 50, 51, 52, 53, 54, 55, and 56.

(Note.—Shocks 26, 45, 65 and 67 were only recorded at the Observatories. Shocks 23 and 47 were recorded at an observatory and at one or two stations.)

From the above we might conclude that 36 per cent. of the earthquakes which shake an enormous area of ground outside Tokio only shake the hilly part of Tokio itself.

From maps of shocks which shook a large area but only shook the hills on the west side of the city, I find from records kept by Mr. E. J. Pereira of Yokohama, which lies from Tokio about 16 miles S.S.W., that at least 10 such shocks were felt in Yokohama. Had Mr. Pereira been provided with a proper instrument, or had he had the assistance of other observers, it is probable that he might have recorded a still greater number of this particular kind of disturbance.

I.

Shocks which shook a large area of country and the whole of Tokio :—

THE NO. OF THE SHOCK.	PERIOD IN SECONDS.	AVERAGE PERIOD.	AREA SHAKEN IN SQ. RI.
2	.2	1.1	1362
16	1.5	1.25	2260
19	.6	—	—
83	3.7	2.	3440
60	1.2	.7	4060
66	.8	.77	5080
—	—	—	—
Average.....	1.33	.76	3240

## II.

Shocks which shook a large area of country, but which only shook the hilly part of Tokio :—

THE No. OF THE SHOCK.	PERIOD IN SECONDS.	AVERAGE PERIOD.	AREA SHAKEN IN Sq. Ri.
1	2.4	2.5	1460
3	—	—	670
7	1.2	1.66	1710
12	.5	—	—
17	—	—	720
28	1.8	1.3	1480
32	—	—	180
34	1.4	1.4	1680
35	—	—	730
36	2.4	2.2	2630
38	2.1	1.4	9670
40	—	—	160
41	—	—	880
46	—	—	170
48	3.2	2.5	5220
50	—	—	580
51	—	—	580
52	—	—	690
53	.2	—	520
54	—	—	1470
55	.8	—	1990
56	.8	—	1990
Average.....	1.52	1.85	1680

From the above tables, which give the period and area shaken by each of these shocks, we see that the shocks which disturbed the whole of Tokio had on the average at the same time each shaken a much larger area than those which were only noticed on the high ground.

Further, those which were felt by the residents on the low ground had on the average a much shorter period than those which were only felt on the high ground.

This latter observation may explain why so many shocks are not recorded on the low ground.

Another explanation is that in many instances a vibratory motion passing beneath Tokio may only reach the surface where the superincumbent soft materials are thin, that is upon

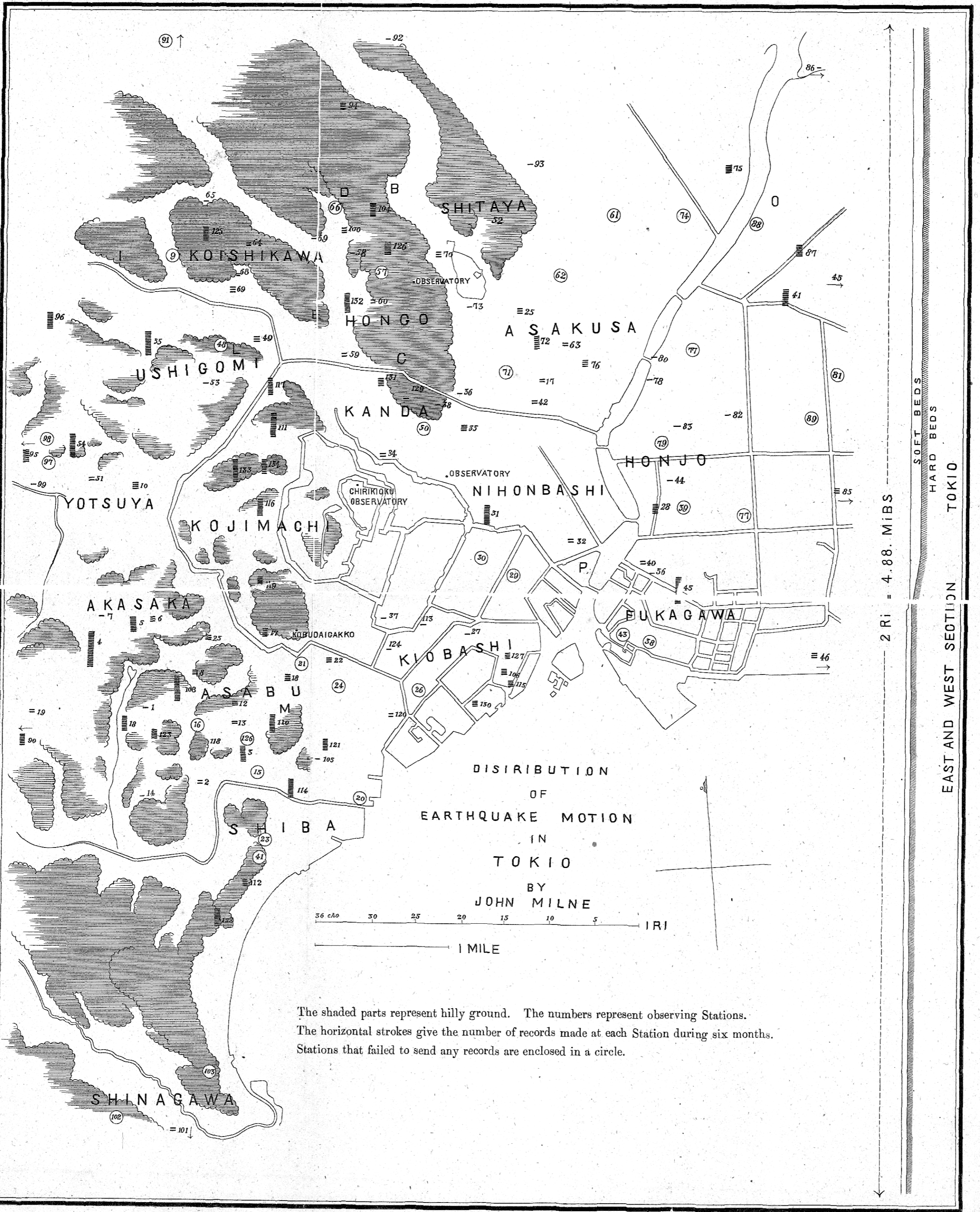
the hills,—the relatively thick deposit of soft material on the low ground absorbing the motion like a buffer.

There were 19 shocks which the instruments at the Imperial Observatory did not record. Out of the 19, however, 8 disturbances had been felt by one observer only, and therefore we cannot say with certainty that there were more than 11 shocks which the Central Observatory failed to observe. On the other hand, there were 10 shocks recorded at the Observatory which were not observed by any of the 134 observers in the city. The most probable reason why 11 earthquakes were unrecorded at the Observatory is because these disturbances were too limited in area to reach the Chiri Kioku. One conclusion we arrive at is that a set of Seismographs located at the observatory in a city like Tokio, no matter how carefully they may be looked after, cannot be expected to record more than 80 per cent. of the total number of earthquakes felt in that city.

Another conclusion resulting from these observations is that residents on the high ground upon the Western and Northern sides of Tokio feel more earthquakes than residents who live upon the low ground towards the South and East. One explanation of this may be that the movement upon the low ground is slower than that on the high ground, but to place this explanation on a more certain foundation it is necessary to make instrumental observations.

A certain number of earthquakes, however, appear to have originated beneath the high ground in the Kojimachi-Akasaka districts, and do not appear ever to have extended to the low ground. This fact will always make the high ground disturbances more numerous than those felt upon the low ground. When I was resident within the area of local disturbances near Toranomōn I came to the conclusion that these local shocks might in many instances be recognized by their character, which is that of a small but sudden little tip from beneath, the vibrations, which only continue 2 or 3 seconds, causing hanging lamps to oscillate vertically.





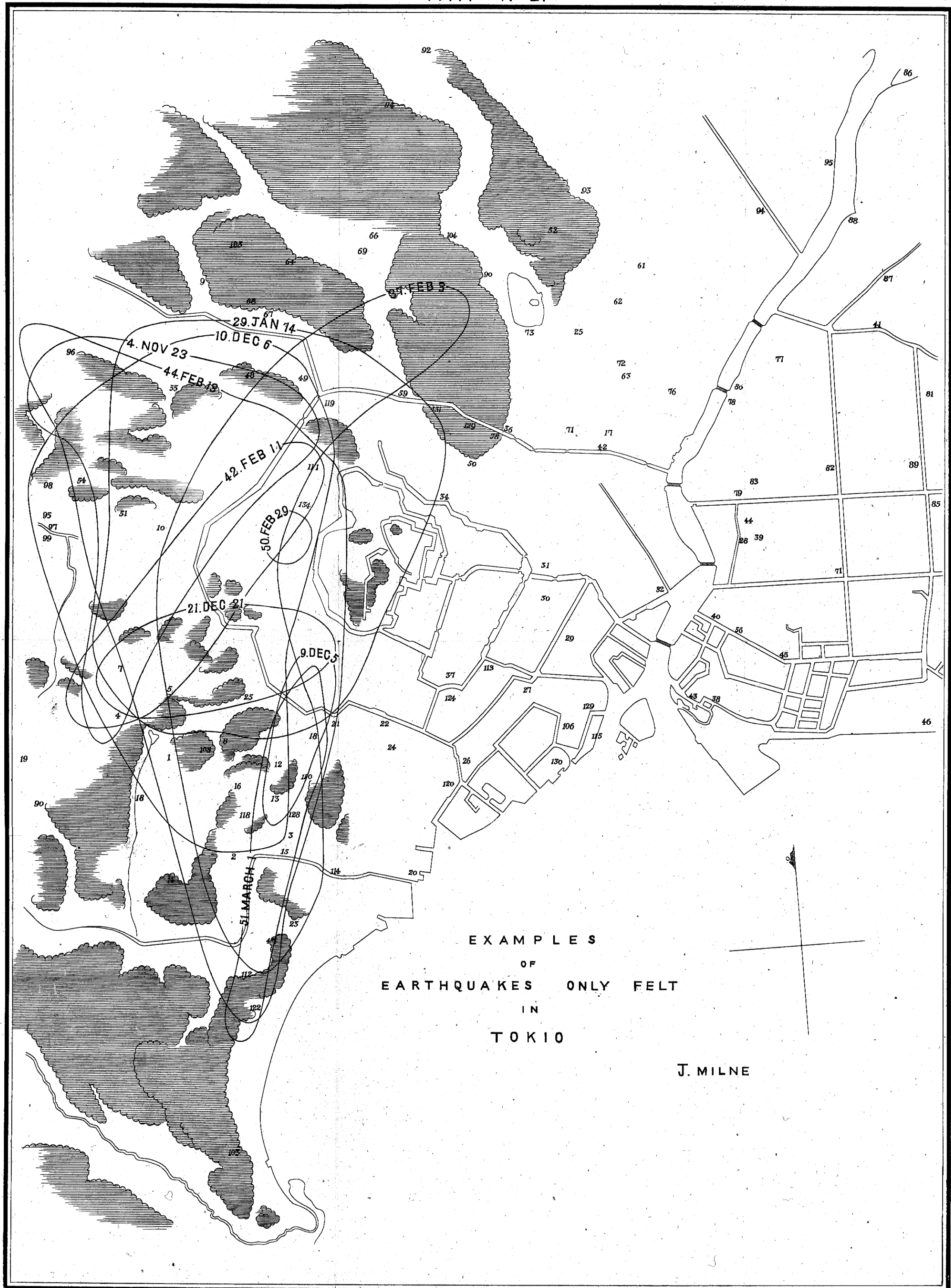
DISTRIBUTION  
OF  
EARTHQUAKE MOTION  
IN  
TOKIO  
BY  
JOHN MILNE

The shaded parts represent hilly ground. The numbers represent observing Stations.  
The horizontal strokes give the number of records made at each Station during six months.  
Stations that failed to send any records are enclosed in a circle.

2 Ri = 4.88. Mils

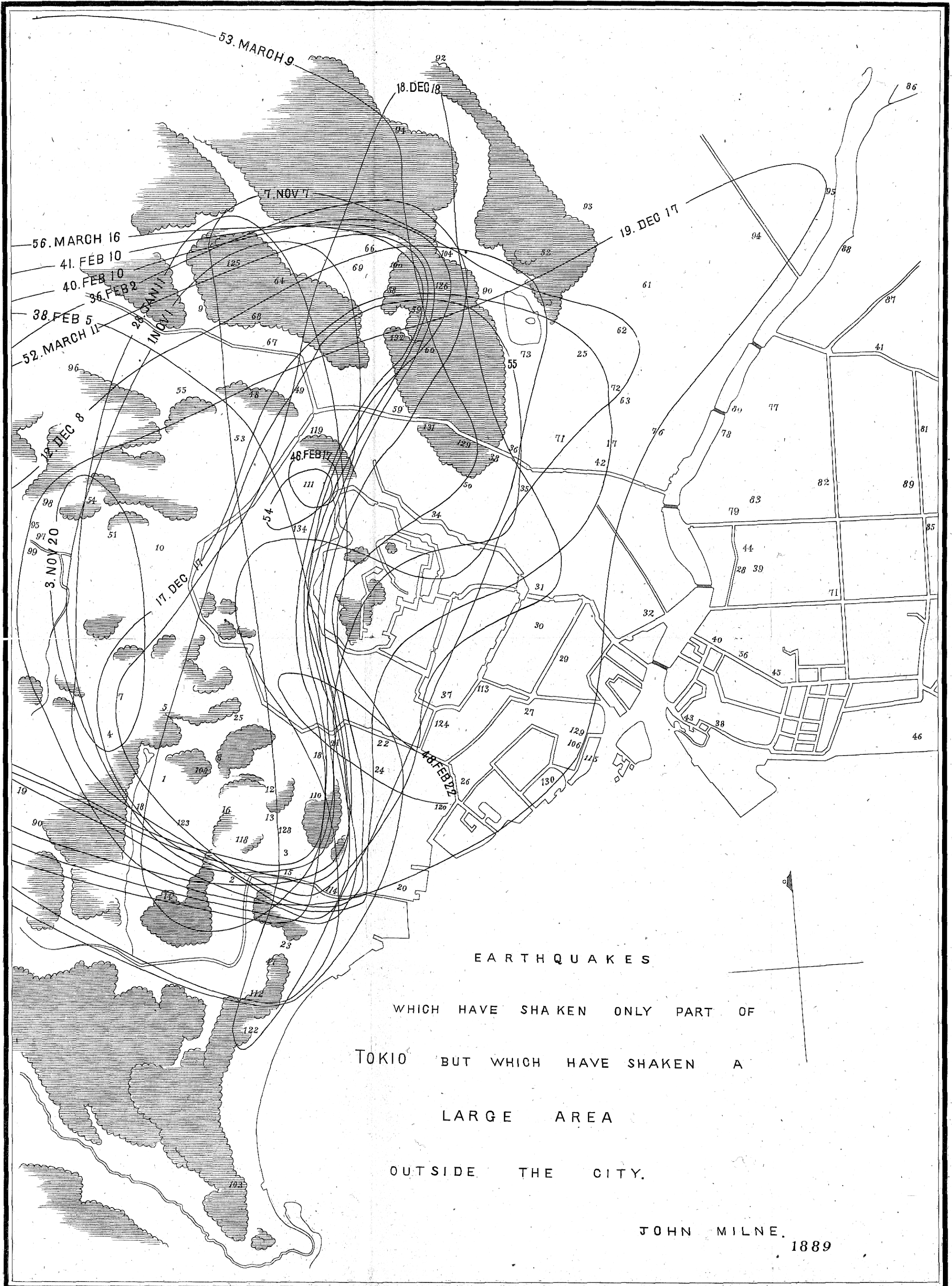
SOFT BEDS  
HARD BEDS  
EAST AND WEST SECTION TOKIO





EXAMPLES  
OF  
EARTHQUAKES ONLY FELT  
IN  
TOKIO

J. MILNE



EARTHQUAKES  
WHICH HAVE SHAKEN ONLY PART OF  
TOKIO BUT WHICH HAVE SHAKEN A  
LARGE AREA  
OUTSIDE THE CITY.

So far as safety is concerned, I am yet of opinion that the high and hard ground is better than the low soft ground, on which earthquake motion, when it is felt, is always greater than it is upon the high ground, and where destruction has almost always been relatively excessive.

