

THE DISTRIBUTION OF SEISMIC ACTIVITY IN JAPAN.

By J. MILNE.

[*Read January 26th, 1881.*]

The following paper on the distribution of Seismic action in Japan is but little more than a compilation of facts derived from communications which I have received from different parts of Japan respecting the number of Earthquakes which have been felt in various districts.

These communications were answers to letters which I sent to foreign residents in various parts of the country, who a few years ago were comparatively numerous, and to various public offices. For assistance in dispatching these letters, and the interpretation of the replies which were received, my best thanks are due to Mr. T. Nakano of the Imperial College of Engineering.

In case my correspondent was unable to furnish me with a list of the earthquakes which had been felt in his locality, he was asked to state his opinion as to the average number of shocks which were annually experienced. In answer to my enquiries in almost all cases replies were received, and for these I now tender my best thanks to their senders.

My primary object in making these enquiries was to obtain material which would enable me to construct a map shewing the distribution of seismic activity in Japan, in the same way that the late Mr. Mallet constructed a map for the world.

Although a critical examination of the facts which I have at my command shew that the results which have been obtained relative to this distribution of Seismic action can only be looked at as being approximate, I think that they certainly indicate to us the districts where the shakings are the most numerous and those where they are comparatively rare, or in other words, the districts suitable for the erection of a Seismological Observatory in contra-distinction to those for fragile structures like a Crystal Palace. On the map which accompanies this paper, the average number of earthquakes per year in various districts are indicated by large numerals. These numbers, however, must not be regarded as indicators of the average of the *actual* number of earthquakes which have been felt, because in most cases they only represent the *opinions* of the residents in various districts, and the best of them are only founded on records which have been kept without the aid of instruments. Thus for instance in the neighbourhood of Tokio, where we know from instrumental observation that there are at least 60 or 70 earthquakes experienced every year, the average numbers on the map are from about 8 to 20. In Tokio I have on several occasions questioned residents who have no special interest in seismological observation as to the number of shocks they imagine they feel during the year, and the usual reply is "about 20." Here we see no doubt for very obvious reasons which need not be entered into,—and it is the same in all other districts,—that popular opinion considerably underrates the actual conditions, and therefore if we wish to know the average of the *actual* number of earthquakes which occur

in various districts, the numbers which I have given must be multiplied by a certain factor. For the districts round Tokio this factor we can see by reference to the map and comparison with tables of the earthquakes which have been recorded by instruments since 1872, (see Transactions of the Seismological Society Vol. II, "Notes on the Recent Earthquakes of Yedo Plain, and their effects on certain Buildings, by J. Milne," p. 14,) varies from about 5 to 10. If for the whole of Japan we take 5 as our factor, I think that we shall obtain numbers considerably under, rather than over, what actually occurs.

In looking over these various records it will be seen that many districts have had periods of unusual activity. Thus for instance, whilst Nagasaki for the last few years only experienced some 3 or 4 shocks per year, during last May it suddenly assumed such an active state that no less than 7 shocks were recorded in one day.

Spasmodic actions like these, which are no doubt to a greater or lesser extent characteristic of all portions of an earthquake country, have in my calculations on the average activity of a district, been omitted.

Lastly I would call attention to the fact that my paper is only supposed to deal with the *present* distribution of seismic action in Japan. I mention this because seismic action although taken as a whole is probably on the decrease so that there is a future when Seismological Societies may cease to exist, still the action in any particular district may at the present time be either decreasing or increasing; and in consequence we get the phenomenon of seismic intensity shifting in its scene of action.

In the following account of the activity of various districts, I have commenced with those in the North and from them gradually proceeded to the South.

Sapporo.—The following list of the earthquakes felt in Sapporo was given to me by Mr. N. Fukusi, director of the

Kaitakushi Survey and Meteorological Department. The letters H, T, K, and Hs, which are attached to some of the earthquakes &c., respectively mean that they were also felt in Hakodate, Tokio, Kamaishi and Hirosaki.

No.	Year.	Month.	Day.	Time (local).	Remarks.
1	1876	IX	25	11.30 P.M.	Medium.
2	—	XII	16	11.45 A.M.	One shock, duration 5s.
3	1877	X	25	6.45 A.M.	Slight.
4	—	XI	20	6.10 A.M.	„ H. K.
5	—	XII	3	3.40 P.M.	„
6	—	—	25	9.30 A.M.	„ T.
7	1878	IV	30	10.13 P.M.	Two strong undulations.
8	—	VII	25	7.45 A.M.	Slight. H.
9	—	VIII	15	1.00 A.M.	„ H.
10	—	XI	5	0.55 P.M.	Strong, duration 45s. H. T. K.
11	1879	III	1	11.03 P.M.	Medium duration 30s. H. T.
12	1880	I	11	8.14 A.M.	„ H. Hs.
13	—	II	20	4.45 A.M.	Slight H.
14	—	VIII	24	7.30 A.M.	„
15	1881	II	2	7.34 P.M.	„ H.
16	—	—	16	2.04 A.M.	„
17	—	—	17	2.30 A.M.	„
18	—	IV	18	3.55 P.M.	Strong and sharp, duration 150s. H. T.
19	—	—	21	10.50 P.M.	Strong and sharp, duration 40s.
20	—	X	25	9.29 P.M.	„ „ „ „ 120s. H. T.

From the above table it would seem that in Sapporo the average number of earthquakes which are felt every year is about four.

During the last six years certainly 10 of the 20 shocks which have been recorded were also felt in Hakodate, and out of these 10, four were propagated as far as Tokio.

As felt in Sapporo, these four shocks (Nos. 10, 11, 18 and 20) appear to have been tolerably strong, whilst as recorded in Tokio by instrumental observation, they were certainly feeble. This would seem to shew that the origin of such shocks was very much nearer to Sapporo than to Tokio.

It is probable that shock No. 6 was felt in Hakodate

but not recorded, otherwise it would not have been recorded in Tokio.

There is only one instance where an earthquake was accompanied by a sound and that is No. 2, when a sound "like cracking ice or of falling earth" was recorded.

Hakodate.—The following record of earthquakes felt in Hakodate has been compiled from two lists,—one which was sent to me by Capt A. P. Porter of Hakodate, and the other which I received from Mr. N. Fukusi of Sapporo.

No.	Year.	Month.	Day.	Time (local).	Remarks.
1	1876	III	14	5.50 A.M.	Slight.
2	—	VII	28	11.02 A.M.	"
3	—	IX	6	3.45 A.M.	Rather strong.
4	—	XI	30	4.00 A.M.	Strong.
5	1877	II	8	4.45 P.M.	Slight.
6	—	IV	30	4.35 A.M.	Rather strong.
7	—	V	22	2.30 A.M.	Moderate.
8	—	V	26	1.15 A.M.	Slight. T.
9	—	VII	9	7.50 P.M.	"
10	—	XI	20	6.00 A.M.	" S. K.
11	—	XII	23	7.39 P.M.	Strong E. and W. K. T. N.
12	1878	VI	21	7.00 P.M.	
13	—	VII	25	8.00 A.M.	" S.
14	—	VIII	14	00.50 A.M.	Slight. S.
15	—	IX	5	10.02 A.M.	" K.
16	—	—	17	12.00 P.M.	Strong.
17	—	—	21	6.06 P.M.	
18	—	XI	5	0.45 P.M.	Strong S. T. K.
19	1879	II	2	7.38 P.M.	
20	—	—	24	9.55 P.M.	
21	—	III	1	11.08 P.M.	Strong S. T.
22	—	V	9	0.30 P.M.	
23	—	—	11	3.30 P.M.	
24	—	VIII	7	7.40 P.M.	
25	—	IX	6	4.12 P.M.	
26	—	XI	18	11.30 P.M.	
27	1880	I	11	8.12 A.M.	Strong S. Hs.
28	—	II	20	5.00 A.M.	" S.
29	—	III	6	8.00 P.M.	
30	—	VI	24	8.40 P.M.	
31	—	VIII	16	2.55 P.M.	
32	—	—	17	4.00 A.M.	

33	—	IX	4	1.00 A.M.	
34	—	—	29	night A.M.	
35	—	XII	6	„ „	
36	—	XII	23	11.00 P.M.	Slight K. T.
37	1881	II	2	7.30 P.M.	Slight S.
38	—	II	26	2.35 P.M.	
39	—	IV	18	3.42 P.M.	Strong N. to S. duration 2 ^m . S.T.
40	—	V	9	6.32 P.M.	
41	—	X	2	9.30 P.M.	Slight.
42	—	X	25	9.26.20 P.M.	Strong, duration 130 ^s S. T.

The letters T. S. K. Hs and N., mean that the records to which they are attached are the records of shocks which were felt in Tokio, Sapporo, Kamaishi, Hirosaki or Niigata.

From the above table it would appear that in Hakodate about seven shocks are annually experienced. Of the 42 shocks which have been recorded, ten at least were also felt at Sapporo, and seven in Tokio. Of the seven which were felt in Tokio, four form part of a group of ten which extended to Sapporo. Nearly all the shocks which were felt in Hakodate and also in Tokio appears to have been more severe at the former place than at the latter.

Speaking generally on the earthquakes which are felt in Southern Yezo, it would appear that many of them are local, some being only felt in the Sapporo district and some only at Hakodate. A shock which is felt both in Sapporo and Hakodate has in many instances been powerful enough to cross the Straits of Tsugaru to Hirosaki, down the coast to Kamaishi and even as far as Tokio. There is only one instance (See No. 11) with which I am at present acquainted, of a Hakodate-Tokio earthquake finding its way to the North-Western side of Japan which is separated from the Eastern side by a high and broad range of mountains.

The fact that the shocks which are felt in Sapporo, Hakodate, Kamaishi and Tokio are seldom felt on the Western side of Japan would seem to indicate that such shocks had their origin in the ocean to the Eastward, and

that the massive range of mountains which forms the median line and backbone of Japan, prevents their being propagated to the West.

As a confirmation of the view that certain of these earthquakes have originated at sea, it may be mentioned that on April 18th, Mr. J. Snow on board the *Otome* in Lat. $142^{\circ}12'$ N. and Long. 145° E. recorded a trembling of the vessel and a low rumbling lasting about $\frac{1}{2}$ a minute. This commenced in Tokio mean time at about 4.41.0 p.m. The position where this record was made is about 200 nautical miles N. 82° E. from Hakodate. In Hakodate and Sapporo the shock was sharp and strong. In Tokio it was so feeble that nothing more than the fact that an earthquake had taken place could be recorded.

Hirosaki.—The following notes on the earthquakes felt in Hirosaki, I obtained from Mr. R. F. Kerr formerly a resident in that town.

Mr. Kerr arrived in Hirosaki in June 13th, 1879, and the earthquakes he felt between that date and March 6th, 1880, were as follows.

1879: in August at night time there was a shock.

1880: January 11th at 7.40 a.m. there were two well defined shocks each lasting two or three seconds, the interval between them being the same as the period over which they extended. They caused East and West windows to rattle sharply, and Mr. Kerr therefore thinks it probable that the shocks were more in an East and West direction than North and South.

1880: in the middle of February about 9 p.m. there was a slight shock.

1880: March 6th at 8.09 a.m. (local time) there was a shock lasting about 35 seconds. The motion which was that a slight series of bumps sufficient to rattle dishes on a table, was from North to South.

The last communication I had from Mr. Kerr was in April 1880, up to which time no shocks had been felt.

*Awomori Ken, Kamikita Gonyakusho.**—In this district it shakes about 10 times every year. The direction of the motion is W.N.W. Before a shaking the mountains emit a sound.

Iwate Ken, Kunohe Gonyakusho.—During a period of four months, from the 1st to the 4th month of the 13 year of Meiji (January to April, 1880,) it shook four times in this district.

The motion is thought to have been from North to South. We do not know whether any sound accompanied the shaking.

Rikuchiu, Kamaishi.—Mr. G. Purcell who was for some years resident in Kamaishi, gave me the following list of earthquakes which he had felt at that place.

Shocks which were also felt in Tokio, Hakodate, Niigata or Sapporo are respectively marked T. H. N or S.

Year.	Month.	Day.	
1. 1877	IX	20	
2. —	X	5	T.
3. —	XII	10	T.
4. —	—	22	T.
5. —	—	23	} Two shocks East & West H.N.T.
6. —	—	25	
7. 1878	VIII	7	East and West.
8. —	IX	5	T. H.
9. —	—	6	
10. —	XI	3	
11. —	—	5	T. H. S.
12. 1879	I	6	
13. —	III	7	

Taking the year all round, Mr. Purcell thinks that there are more earthquakes to be felt in Kamaishi than in any other part of Japan where he resided. They are most nu-

* *Gonyakusho* signifies District Office.

merous from August to December. In 1878 there was a constant succession of shocks. They commenced about 8 a.m. rather heavy and continued all day about every half hour until about midnight. They appeared to be from West to East when in the house, but from the experience of others it would seem that they must have come down the valley which runs North and South. One exception to this was a heavy silent shock which seemed to come from the sea. Mr. Purcell says the shocks were always heralded by a rumbling roar sometimes lasting two minutes before the shaking commenced. A noticeable point was that the greater the noise the less was the shock, and sometimes there was a rumble without the shock. There appeared to be a very close connection between the shocks and the state of the atmosphere. A description of the series of shocks which were felt some years ago in Yamaguchi Ken by a foreign resident exactly corresponds as to the phenomena of the sound with that which Mr. Purcell states.

A similar phenomena was observed in connection with the destructive shocks which were recently experienced at Agram.

From an examination of the above table of shocks experienced in Kamaishi it would seem that at least 50 per cent of them are also felt in Tokio, and about 25 per cent of them in Hakodate. This fact, coupled with an examination of the records of other localities in North Japan, would seem to shew that the greater number of the Kamaishi shocks have an origin nearer to Tokio than to Hakodate, and their origin probably lies out at sea. As a regular record of the Kamaishi shocks is now being kept, I hope shortly to be able to write more definitely on the subject.

Akita Ken, Yamamoto Gunyakusho.—In this district earthquakes occur but seldom. There may be shocks say once or twice a year. They are weak and sounds are never

heard. However when there is a violent shock a detonation is heard. This may be once during a period of from 7 to 10 years.

Akita Ken, Innai.—From May 1879 until March 1880, Mr. C. Banza says that he neither felt an earthquake nor did people from whom he had made enquiries. Shakings however occasionally occur. Thus this year on January 6th at 5.30 A.M.; January 11th at 5.40 A.M., and again at 7.00 A.M. small shocks were felt. It would seem that these shakings were local.

Akita Ken, Kubota.—Mr. C. Carrothers who wrote to me from Akita on March 10th, 1880, says that earthquakes are not frequent in Akita, and when they do occur they are either slight or very slight. During nearly a years' residence only one was felt. This was on the 25th February, 1880. This shock was chiefly remarkable for its length, continuing as a succession of shocks over nearly a minute. It seemed to come from the East. The people told Mr. Carrothers that other shocks had been felt, but he himself had not noticed them. There are no volcanos in the neighbourhood, but there are some hot sulphur springs in the mountains to the East. Mr. Carrothers never heard of any damage having been done by earthquakes in Akita.

Akita Ken, Ani.—Mr. H. Metzger writing to me from Ani says, that although he has been carefully on the look out for earthquakes from May 3rd, 1879, until he wrote to me February 3rd, 1880, not a single shock was felt.

Yamagata Ken, Higashi Murayama Gonyakusho.—In this district the ground shakes about 5 or 6 times every year. Sometimes it is strong and sometimes weak.

Miyagi Ken, Natori Gonyakusho.—In this district it shakes from 14 to 18 times per year and a sound like the roar of thunder is heard. Violent shakings are rare. It is said that because this district is mountainous, strong earthquakes are never disastrous.

Miyagi Ken, Kunbara Gonyakusho.—In this district it usually shakes from 15 to 23 times in a year. The motion is thought to come from the North-West. There is no sound either before or after the shaking.

Miyagi Ken, Sendai.—Mr. C. L. Gould writing to me from Sendai says that the number of earthquakes felt per year in that town does not exceed five or six. They are mostly very slight. This is the estimate of observant natives and it agrees with Mr. Gould's experience.

Fukushima Ken, Tamura Gonyakusho.—We do not now hear about violent shakings such as might destroy houses. The number of earthquakes per year is from 13 to 16. One year there were only 3 or 4 shakings. Earthquakes usually occur during the winter and they come from the South-West. Previous to a shaking a sound is heard. The common people say that if during the winter it should be warm, earthquakes will be few, and such things foretell a famine.

Niigata Ken, Yechigo, Iwafune Gonyakusho.—In this district it shakes about twice a year and the shakings are weak. The direction of the motion is probably from N.W. to S.E. A few seconds before an earthquake a roaring sound is heard.

Niigata Ken, Kariha Gonyakusho.—We feel earthquakes from 2 to 6 times per year. Houses were not destroyed even by the earthquake of the 4th year of Kokwa, 1847. They were, however, damaged. The motion is thought to come from the South-West. 'Since the year of Kokwa no sound has been heard.

Niigata Ken, Niigata.—The following is a record of the earthquakes felt in Niigata, made by Captain Fagg of that port.

The shocks which were also felt in Tokio, Hakodate or Kamaishi are respectively marked T, H, or K,

- 1 1875 None.
- 2 1876 Sept. 1st, evening.
- 3 1877 Oct. 5th, 7 p.m., K.T.
- 4 1877 Dec. 23rd, 7.30 p.m., H.K.T.
- 5 1878 Feb. 23rd, 6 a.m., T.
- 6 1879 Nov. 27th, a.m.
- 7 1879 Dec. 16th, a slight shock T.

All these shocks were very gentle. The only severe one which Captain Fagg remembered was in 1871.

From the above table we see that the average number of shocks felt in Niigata is about two per annum.

Of the seven shocks which have been recorded, four were felt in Tokio. Of the four shocks felt in Tokio, three of them gave the greatest disturbance in the S.S.W. and N.N. E. mercury tubes of Palmièri's instrument.

Island of Sado.—Mr. James Scott writing to me from Sado says that Japanese believe that shocks are never felt in that island. However in 1872 Mr. Scott felt a sharp short shock, and on November 28th 1879, at about 8.30 P.M. there were two shocks succeeding each other at short interval. They were accompanied by a low rumbling sound. It seems probable that these may have been also felt in Niigata. In a second communication from Mr. Scott dated March 21st, 1881, he says at exactly 2.33 A.M. this morning we had a sharp shock. The old people say that they had not felt anything like it for years. Although it was perfectly calm the bamboos close to my window made a noise like that of a stiff-breeze. The motion which felt as if one were standing on the harp of a grist mill with a motion of about 1½ inches and making 140 to the minute, only lasted about 15 seconds.

In 1880 on August 18th, at 7.45 A.M. we had a shock.

Mr. Scott resided in Sado for about 11 years.

Tochigi Ken, Kawachi Gunyakusho.—At Utsunomiya we should say that there are earthquakes 2 or 3 times every

month. The direction of the motion is from N.W. or W.N.W. to S.E. or E.S.E. The intensity is from 15° to 16°. Shocks of over 30° only happen once or twice per year. The time at which they occur is not fixed, but they are most common at midnight and early morning. The roaring is sometimes loud notwithstanding that the shaking may be weak, and it lasts 15 or 16 seconds.

Chiba Ken, Ichimi Gunyakusho.—In this district shocks occur very often but they are usually weak, the reason probably being that this district is sandy. The time at which they occur is clearly the same as that we see published in the newspapers about the Tokio earthquakes. As we have no seismometer we cannot tell the strength of the shocks.

Chiba Ken, Katori Gunyakusho.—Every year we feel about 8 or 9 earthquakes and the movement appears to be from the South-West. We do not hear any sound. The people say that after an earthquake there will either be rain or wind.

Ibaraki Ken, Niiharu Gunyakusho.—The following is a list of the days on which earthquakes were felt during three years,—from the 9th to the 11th year of Meiji (1876—1878).

The shocks which were also felt in Tokio are marked T.

No.	Year.	Month.	Day.	
1	1876	3	19	T.
2	—	3	30	T.
3	—	4	11	T.
4	—	4	17	T.
5	—	5	7	T.
6	—	6	25	T.
7	—	9	3	
8	—	10	10	
9	—	11	2	
10	1877	1	25	
11	—	2	16	T.
12	—	3	18	

13	—	5	6	
14	—	7	8	
15	—	9	10	
16	—	10	26	
17	—	11	3	
18	1878	1	23	T.
19	—	3	12	T.
20	—	3	21	
21	—	4	16	
22	—	4	20	
23	—	4	25	
24	—	5	6	
25	—	9	3	
26	—	9	30	T.
27	—	10	20	

Out of the 27 earthquakes here recorded it is probable that nine of them were felt in Tokio, there being earthquakes recorded on corresponding days.

None of them appear to have been recorded in Kamaishi, Niigata, Hakodate or Sapporo. Sixty per cent of the earthquakes would therefore seem to be local.

Gumma Ken.—In this district there are earthquakes about 2 or 3 times during the year. As this Ken is surrounded by high mountains and stands on a firm foundation, tradition tells us that there will never be any destructive earthquakes in this country. A noise accompanying the shock is never noticed.

Nagano Ken, Shimotakai Gonyakusho.—Since the opening of this office, it shook twice last year (1879) and once this year (September 1880). We do not know the direction of the shaking, and we do not remember having heard any noise.

Nagano Ken, Kami Ina Gonyakusho.—From the 1st to the 13th year of Meiji (1868-1880) the ground shook more than 20 times.

In the 5th year of Meiji (1872) there were four shocks, and in the 2nd year (1869) three. Some years we had no earthquakes. All of them have been weak and they are supposed to come from the South-West. Even those of the years of Kokwa (Zinkoji in 1847) and Ansei (Tokio in 1854), were not so violent and no buildings were destroyed.

Tokio and Yokohama Districts.—During the last year 1881, 59 shocks were recorded at the Meteorological Observatory by one of Palmieri's instruments. In 1880, 74 shocks were recorded. As an average for the last six years we may say that each year about 63 shocks have been observed. A catalogue of these shocks has been given in the second volume of the transactions of the Seismological Society. (Notes on the Recent Earthquakes of Yedo Plain, &c., by J. Milne).

As Tokio, Yokohama, and many neighbouring places are supplied with seismographs, and means have been taken for the recording of all the earthquakes which are felt in the districts of North Japan,—this having been done with the primary object of determining the origins of the shakings we experience,—I will for the present withhold an account of the shocks of the Tokio district until I am able to present it to the Society in a more detailed form.

Sagami, Osumi and Suyeaya Gonyakusho.—We have usually 5 or 6 earthquakes every year. This year we have had six (May 7th, 1880). Since the shock of 1854, the one on the 21st at 1.30 A.M. (Feb. 22nd 1880?) is thought to have been the most violent. The direction of motion was from North-East to South-West. No sound was heard.

Kai, Nishi Yamashi Gonyakusho.—As an average for the last three years (1878-1880) we should say that there are about 11 shocks per year. A sound is heard before the shaking.

Idzu Shidzuoka Ken, Kamo and Naka Gunyakusho.—

We do not know anything about the earthquakes of last year (1879). From the end of April to the commencement of May this year, shocks were often felt on the shore to the Eastward. At Itomura there were 25 or 26 shocks in one day, at other times 3 or 7 shocks per day. The direction of these shocks was from N.N.W. to S.S.E. A noise was heard before the shaking.

Shidzuoka Ken, Hikisa Aratama Gunyakusho.—There was a very strong earthquake in the fourth year of Hoyei (1707), and again in the first year of Ansei (1854).

Feeble shocks are felt 2 or 3 times per year. From 5 to 8 minutes (seconds ?) before the shock we hear a sound.

The earthquakes since the 1st year of Ansei (1854) are as follows.

	<i>Violent. Weak.</i>	
Ansei 1st year, between the 11th and 12th month, (1854 20th Dec.—1855, 18th January)	4	53
" 2nd " 1855.....	6	15
" 3rd " 1856.....	2	
" 4th " 1857.....		3
" 5th " 1858 unknown		
" 6th " 1859.....		1
Manyen 1st year 1860.....		2
" 2nd " 1861.....		1
Genji 1st year 1864.....		2
Keiwo 1st year 1865.....		2
" 2 & 3rd year 1866 & 1867 unknown ...		
Meiji 1st year 1868 unknown.....		
" 2nd " 1869		1
" 3rd " 1870		3
" 4th " 1871		4
" 5th " 1872		1
" 6th " 1873 to 1877 unknown		
" 11th " 1878		1
" 12th " 1879 .....	..	2
" 13th " 1880		2

Yechizen Ishikawa Ken, Nebi Gonyakusho.—We have made enquiries but did not hear about any earthquakes.

Yechizen Ishikawa Ken, Ono Gonyakusho.—As we are situated amongst the mountains, earthquakes are only felt say from 3 to 7 times per year. Their duration is from 15 to 30 seconds. Their direction is not known, but a sound is sometimes heard.

Ishikawa Ken, Noto Kashima Gonyakusho.—In this place we usually feel from 3 to 4 shocks per year. At about 4 p.m. on the 26th of February of this year 1880, and at about 10 a.m. on the 9th of March there were slight shakings. We do not know anything either about the sound or their duration.

Gifu Ken, Fuwa Gonyakusho.—As we are without seismometers we can not give you any information.

Gifu Ken, Hida, Ono, Masuda and Yoshiki Gonyakusho.—On the 25th day of the 7th month of the 9th year of Bunsei (August 28th 1826) and on the 16th day of the 12th month (January 3rd 1827) it shook very violently. Yoshikigori suffered severely. Many portions of the mountains slipped away, and a large rock 6 or 7 ken in length (36-42 feet) was destroyed.

At about 1 a.m. on the 26th day of the 2nd month of the 5th year of Ansei (April 10th 1858) there was a violent earthquake, and Ono and Yoshiki suffered badly. Many houses, store houses and even mountains were destroyed. People and animals were killed or wounded. Rivers were stopped, floods were occasioned and buildings were swept away.

For 4 or 5 days after the earthquake the ground shook 4 or 5 times every day. At about 2.40 p.m. (a.m.?) on the 23rd of April, 1880, it shook slightly three times. The motions are thought to have been from the North-East. On the 26th of April, at 4.41 A.M., a sound came from the North-West and a shaking continued for 3 or 4 hours, the duration of shock being about 41 seconds.

These shocks do not appear to have been observed in Tokio. Another shock was felt in Mino in 1881, on July 22nd, at 4.30.0 A.M., and another in August, at 10.5.0.

Aichi Ken, Chita Gunyakusho.—We have no earthquake records in our office, and though we have made enquiries we have nothing of value to send.

Aichi Ken, Toyohashi.—Mr. W. Mathews who wrote to me in February, 1880, said that during the last five months he had only felt two shocks, one in August, and one in December.

Miye Ken, Wataraye Gunyakusho.—During the 6th and 11th months of the 1st year of Ansei (July and December, 1854) the ground shook violently. For the last ten years there have been earthquakes 3 or 4 times per year, but they have not been accompanied by any sound.

Shiga Ken, Gamo Gunyakusho.—In this district we feel 1 or 2 earthquakes every year. They come from the North-West or North-East. Previous to the shaking we sometimes hear a sound.

Kioto Fu, Katsuno Gunyakusho.—We feel earthquakes 3 or 4 times in a year.

Kobe.—The following list of earthquakes felt in Kobe was made Mr. H. St. J. Browne.

No.	Year.	Month.	Day.	Time.	
1	1868	IX	11	1.30 A.M.	Severe.
2	—	—	12	1.35 A.M.	Slight.
3	—	—	17	6.00 P.M.	Slight.
4	—	—	18	11.00 A.M.	Severe.
5	—	X	27	4.00 P.M.	
6	—	XI	28	5.00 A.M.	
7	1869	II	18	11.00 A.M.	Severe.
8	—	—	—	—	Several slight shocks.
9	1871	XII	13	6.30 P.M.	Severe.
10	1872	I	2	3.00 A.M.	Slight.
11	—	—	—	8.00 A.M.	”
12	—	II	17	—	Two shocks.
13	—	III	14	6.30 P.M.	
14	—	—	15	8.00 P.M.	
15	—	—	18	12.00 P.M.	
16	—	IV	12	2.00 A.M.	
17	—	IX	29	8.00 P.M.	
18	1873	II	10	8.30 P.M.	Two shocks.

From the 9th April, 1873, to 30th May, 1874, Mr. Browne, owing to his absence, was unable to keep any records.

From May 1874, until February 17th, 1880, although the newspapers reported several shocks, Mr. Browne did not feel any himself.

From September 1868, to September 1872, which comprises the greater portion of the period over which Mr. Browne's list extends, I am not possessed of a corresponding list of the Earthquakes felt in Tokio and am therefore unable to say whether any of these shocks extended as far as Tokio.

Shocks numbers 17 and 18 do not appear to have been recorded in Tokio, and from records of recent shocks it would seem that the Tokio shocks are not felt in Kobe, and the Kobe shocks are not felt in Tokio. Even the shock of February 22nd, 1880, which caused so much damage to Yokohama did not appear to have made itself felt as far as Kobe.

Hiogo Ken, Shikito Gunyakusho.—The ground shakes about once in every two months and the motion appears to come from the South-West. Now and then a sound is heard.

Osaka.—Mr. W. Gowland of the Mint in Osaka tells me that since 1872 when there was a shock that was rather severe, he does not think that there have been more than 10 or 12 earthquakes,—and these have been all small.

Before the shock in 1872 a slight sound was heard; the sound probably being produced by the creaking of the houses in the town through which the shock seemed to pass before reaching the Mint. On August 9th, 1877, when at Mayebara on the E. side of Lake Biwa, Mr. Gowland felt a stiff shock.

This shock was just perceptible in Tokio.

Osaka, Nishinari Gunyakusho.—This office was built

on the 1st day of the 3rd Month of the 12th year of Meiji, (March 1st, 1877) and from that date until now (May 12th, 1880) there have been about 4 or 5 earthquakes. They were all weak and their direction is not known. Settsu seems to be a province where earthquakes are rare.

Wakayama Ken, Nishi Muro Gunyakusho.—The earthquakes which we know about are as follows :

3rd Year of Ansei	1856	4	shocks.
4 " " "	1857	4	"
5 " " "	1858	4	"
6 " " "	1859	5	"
1st " " Manyen	1860	1	"
1st " " Bunkiu	1861	1	"
2 " " "	1862	1	"
3 " " "	1863	3	"
2 " " Keiwo	1866	1	"
1 " " Meiji	1868	1	"
4 " " "	1871	3	"

After the 5th year of Meiji we have no records. During the 1st year of Genji, 1st and 3rd years of Keiwo, the 2nd year of Meiji (1864, 1865, 1867 and 1869) there were no earthquakes.

For 1881 the following records of earthquakes were forwarded by the director of the observatory in Wakayama.

Month.	Day.	Time.	Intensity.
IV	23	6.28.00 P.M.	
VI	30	2.17.20 P.M.	Slight.
VII	11	11.27.30 A.M.	"
VII	17	0.43.30 P.M.	Rough.

None of these shocks appear to have been felt in Tokio.

Hiogo Ken, Tajima Shirosaki Gunyakusho.—Here we feel 2 or 3 small earthquakes every year. The motion appears to be from the mountainous sea-shore on the N.E. and to go to the South-West. Twenty seven years ago all the provinces in Japan were shaken, but this district felt it but slightly.

Okayama Ken, Mino Gonyakusho.—We have earthquakes about twice a year. They are accompanied by sound. The direction of the motion is unknown.

Okayama Ken, Mimasaka, Kume and Nanjo Gonyakusho.—Since the 6th year of Kayei (1852) when houses were destroyed, we have not experienced any violent earthquakes. Now we only feel 2 or 3 shocks during the year. Sometimes we hear a sound. Their direction is not known.

Okayama Ken, Kamifusagori, Takayama, Kamifusa Gonyakusho.—Here we feel about 7 earthquakes during the year—4 in winter and 3 in spring. Previous to the shaking the sound which is heard appears to come from the West.

Okayama.—J. C. Berry writing from Okayama on March, 1881, says that after careful enquiry it would seem that only *very slight* shocks had occurred during the last two years. The shock of February 22nd, was not felt in Okayama.

Shimane Ken, Naka Gonyakusho.—Here it shakes about 10 times during the year. The most violent shock was in the 5th year of Meiji, (1872). As we are without records, it would take considerable time to make an accurate report.

Shimane Ken, Takukusa Gonyakusho.—We have made many enquiries but could not obtain anything to send you. As this district is surrounded by mountains, earthquakes occur but seldom, say 5 or 6 times per year.

Shimane Ken, Hoki, Aimi Gonyakusho.—In this district we have weak shocks one or two per year. They are thought to come from the South-West, and when they are strong, a sound is heard.

Shimane Ken, Shimane, Akishika, Owu Gonyakusho.—At 5 p.m. on the 6th day of the 2nd month of the 5th year of Meiji (March 15th, 1872) there was an East and West shaking. Several houses were damaged. Matsuye was

shaken very badly. Afterwards it shook three or 4 times. We do not know anything about the sound.

This year (up to May 15th, 1880) no one has felt a shock.

Hiroshima Ken, Bingo, Fukatsu and Numakuma Gunyakusho.—As we are without seismometer we can not give any accurate information. The shock which we felt on the 4th day of the 11th month of the 1st year of Ansei (23rd December, 1854) was very strong. It is thought to have come from the East.

We have on an average 3 or 4 earthquakes per year. They are all weak and are usually in the autumn or winter. With some of them there is a sound, and this sound is thought to come from the East.

Hiroshima Ken, Numata Takamiya Gunyakusho.—On an average we have 5 or 6 earthquakes every year. They are thought to come from the North, and before they are felt a sound is heard.

Toyoura Gunyakusho.—When the seasons change we usually feel from 2 to 5 earthquakes. Judging from the sound they would appear to come from the East. They are all slight and persons out of doors do not feel them.

Hiroshima Ken, Hiroshima.—The following records of earthquakes felt in Hiroshima in 1881 were received from the observatory in that town.

Month.	Day.	Time.	Intensity.
VII	10	3.45.00 P.M.	slight.
VII	27	9.00.00 P.M.	„
IX	10	6.30.00 P.M.	„
IX	30	10.25.00 P.M.	„

None of these appear to have been felt in Tokio, Wakayama or Nagasaki.

SHIKOKU.

Uwajima.—The earthquakes felt at Uwajima during 1880 were as follows.

During January two shocks.

„ March 19th, 3.30 p.m., a long shock.

„ August 18th, 9.00 p.m., a feeble shock.

None of these shocks were felt in Tokio.

Iyo Yehime Ken, Sanuki, Mino and Toyoda Gunyaku-sho.—In these districts we feel from 4 to 5 shocks every year. They are thought to come from the West. A sound is heard sometimes before the shock and sometimes after it.

KIUSHIU.

Nagasaki Ken, Higashi Kanokine Gunyakusho.—In this district we have not felt a shock for the last 4 or 5 years.

Nagasaki Ken, Hizen, Nishi Matsura Gunyakusho.—In this district we have feeble shocks once or twice every 3 or 5 years. A shock which we had 6 or 7 years ago was powerful enough to splash the wine out of the casks in the store houses. During recent times this was the most violent earthquake which we remember. Sounds are never heard.

Nagasaki.—One correspondent writing to me in February, 1880, says that some years ago he has felt a dozen in the year. In other years he has only felt two or three. Last year there were four or five. Another correspondent gives me the following list of earthquakes.

1878.—November 20th at 10.44 p.m. a shock from the North.

1879.—October 17th at 7 p.m. a shock.

1879.—November 9th at 7.26 p.m. a slight shock, and he says that there is an average of about 2 shocks per year.

A third correspondent mentions a smart shock which occurred on the 23rd of May, 1873, two others within a few days of each other during the Christmas of 1877, and one in June of 1878. This last shock was felt in Miike.

During the last year, 1881, Nagasaki passed through a period of unusual seismic activity.

The following list of shocks which were then felt were received from the superintendent of the Observatory.

No.	Month.	Day.	Time.	Intensity.
1	V	2	4.10.00 P.M.	Slight.
2	—	22	7.22.00 P.M.	„
3	—	22	7.31.00 P.M.	„
4	—	22	7.42.00 P.M.	„
5	—	22	8.17.00 P.M.	„
6	—	23	10.17.00 A.M.	„
7	—	23	10.08.00 P.M.	„
8	—	24	0.33.00 A.M.	„
9	—	26	4.50.00 A.M.	„
10	—	27	8.16.27 A.M.	„
11	—	31	8.48.00 A.M.	„
12	VII	11	1.19.00 P.M.	„
13	VIII	25	10.10.47 A.M.	„

A correspondent writing on the 27th May, 1881, says that there were seven shocks last Sunday (22nd) doing some damage to property. Another correspondent says the shaking commenced at 7.30 P.M. The most severe shock was about 8.30.0; but between these there were five distinct shocks. They seemed to be from North to South.

None of these shocks were observed in Tokio.

Nagasaki Ken, Saga.—In June 1879 a slight shock was felt. There are about 2 earthquakes per year.

* *Kumamoto Ken, Miike.*—Mr. F. H. Potter in writing to me from Miike on February 15th, 1880, says that since his residence in Miike during a period of 3½ years, although he has several times thought that he felt an earthquake, he has never been quite sure.

In June 1878 there was a shock, which, in Nagasaki, caused people to leave the Church. This was very slight in Miike.

During 1880, there were only two marked shocks, one at 4 a.m. on May 26th, and the other at 9.40 a.m. on November 11th.

Fukuoka Ken, Chikuzen, Fukuoka Kurate Gunyakusho.—We have no accounts of earthquakes to send you.—Earthquakes are rare.

Fukuoka Ken.—About two shocks are felt here per year.

Oita Ken, Miname Umibe Gunyakusho.—We have no written records of earthquakes, but remember that on the

5th and 7th day of the 11th month of the 1st year of Ansei (December 24th and 30th, 1854) the ground in our district was violently shaken. Since that time we have had 3 or 4 weak shocks per year. When the shocks are violent a sound is heard, but usually nothing is heard. At 2 p.m. and about 9.20 p.m. on the 23rd and at 5.40 a.m. on the 24th of last month (June 1880) there were slight shocks, but without a sound.

Oita Ken, Uta Gunyakusho.—Violent earthquakes are very rare. As an average of the last 10 years we should say that there are about 10 shocks per year. We never hear any sound.

Oita Ken, Nawoiri Gunyakusho.—In this district it usually shakes 3 or 4 times per year. The average for the last 5 years is about 3 shocks per annum. The motion is feeble and its direction is from North to South. Occasionally we hear a sound. This place is situated 12 ri (29 miles) from the shore. To the South-West there are many high mountains which run towards the coast to the North-East.

Hiuga, Nobeoka, Usuki Gunyakusho.—We feel about 3 or 4 shocks every year.

Kagoshima Ken, Kagoshima Gunyakusho.—In this district we feel earthquakes 2 or 3 times every year. They are thought to come from the North-East. Before the shaking we hear a sound. In October 1879, and March 1880, there were three slight shocks. Another correspondent thinks that there are about 4 shocks per year.

Kagoshima Ken, Takagi and Idzumi Gunyakusho.—In this district we feel 2 or 3 shocks per year. Their direction is not known. At 2.30 p.m. on the 10th day of the 6th month (June 10th, 1880) a shaking came from the South-East. As usual we did not hear any sound.

Kagoshima, Hiuga, Murakata Gunyakusho.—At about

5 p.m. on the 4th day of the 11th Month of the 7th year of Kayei (1st year of Ansei? December 23rd 1854) the ground was shaken from the North-East to the South-West. Several buildings and the walls of houses were broken and portions of the mountains slipped away. During the succeeding week the shakings continued, but no one was wounded. Many of the old people said that these were the most violent which had occurred since the eruption of Sakurajima in Osumi. We therefore consider this earthquake to have been a serious one, although it was very weak as compared with that which was felt in Tokio and Yokohama. In recent times we have only had 3 or 4 shocks per year, and those who are out of doors allow them to pass by unnoticed.

Kumamoto Ken, Higo Aso Gonyakusho.—The district is surrounded with mountains. From East to West it measures 10 ri (24 miles) and from North to South 20 ri (49 miles). In the centre of this district stands Mount Aso which blows out fire both day and night. The earthquake of the first year of Ansei (1854) was, as compared with what was felt in other districts, very weak. Usually we feel only 2 or 3 shocks per year and these are very weak and unaccompanied by any sound.

Kumamoto Ken, Yatsushiro Gonyakusho.—As Yatsushiro Gori is bordered on the South-West by the sea and on the North-East by valleys and mountains, earthquakes are felt but seldom. Usually there are not more than 3 or four shocks per year. Both before and after these shocks a sound is heard. The shaking is thought to come from the shore. As we are more than 15 ri (37 miles) distant from Mount Aso, the sound of it can not be heard.

Kumamoto.—Here there are about 2 shocks felt every year.

Kokura.—About two shocks are felt here per year.

PHILIPPINE ISLANDS.

The following list of Earthquakes felt in the Philippines is given for the purpose of comparison with those felt in Japan :—

MANILA 1881.		Lat.	Long.						
1	Alcala.....	17.48. 0	127.45.40	III	16	4.45.00 A.M.	Swift.		
of San Fernando.									
2	Pulloc.....	17.46.25	127.17.00	IV	25	10.09.30 A.M.	Small.		
3	Talalan	17.45.00	126.37.00	IV	25	10.20.00 A.M.			
			h. m. s.						
4	Tuquegarao	17.36.42	8 31.29	I	21	5.31.00	Strong.		
5	Lingayen	16.02.30	126.26.25	II	21	4.00.00 A.M.			
6	Cabanatuan	15.31.50	127.10.00	IV	16	11.37.00 A.M.	Moderate.		
7	San Isidro	15.20.30	127.06.00	IV	16	11.39.00 A.M.	"		
8	Manila "	14.35.25	127.09.33	II	"	9.15.00	Small.		
9	Sta. Cruz de la Laguna	14.18.00	127.37.00	IV	17	2.15.00 A.M.	Unknown.		
10	Taal.....	13.58.00	127.07.00	II	3	5.30.00 A.M.	Swift.		
11	Balangas.....	13.50.00	127.15.00	II	3	5.36.00 A.M.	Strong.		
12	Albay	13.09.00	129.54.00	II	12	6.12.00 P.M.	Small.		
13	.....	—	—	—	—	7.09.00 P.M.	Unknown.		
14	.....	—	—	—	4	0.00.00	Small.		
15	.....	—	—	—	20	7.35.00 A.M.	Strong.		
16	.....	—	—	—	12	1.40.00 P.M.	Unknown.		
17	Iloilo	10.42.30	128.46.30	III	12	0.00.00	Very strong.		
18	Surigao	9.42.30	131.40.30	II	7	3.80.00 P.M.	"		
19	Mainit.....	9.02.00	131.50.25	III	23	3.30.00 P.M.	Unknown.		
20	Butuan	8.50.40	131.51.10	III	23	3.30.00 P.M.	"		
21	Bunauan	1.32.20	131.56.25	III	7	11.00.00 P.M.	Unknown.		
22	Loreto	8.31.25	131.28.40	III	23	3.30.00 P.M.	"		
23	Basilig	8.12.15	132.29.00	III	14	1.30.00 P.M.	"		
24	.....	—	—	—	14	10.00.00 P.M.	"		
25	Talacogon	8.07.30	131.24.00	II	18	9.30.00 P.M.	Strong.		

The 25 records which are here given appear to represent 20 earthquakes, three of which were felt at two places and one at three places.

The fact that observers at the 20 stations of which the names are given in the preceding list, should not in many instances have recorded the same shock, indicates that the shocks only extend over limited areas. By comparing this list with a list of earthquakes felt during the early part of 1881 in Tokio, it seems that although earthquakes have in a few years been felt in Tokio on the same day as shocks were experienced in the Philippines, in no case are the times at which these shocks were felt sufficiently close for us to suspect that they were disturbances having the same origin.

CONCLUSION.

The most general result to be drawn from the various records which have been given is to be seen in the accompanying map, on which a series of larger numerals shews the average number of earthquakes which are annually felt in various districts. In order to obtain the *actual* number of earthquakes felt, as I have before explained, it would be necessary to multiply each of these numbers by some factor like 5. As records of earthquakes are now being made in various parts of Japan,—for which up till now we have simply had to depend upon the opinion of the inhabitants as to what the annual number of shocks were in those districts—in a few years time it will no doubt be possible to construct an earthquake map for this country far more accurate than the one which I now lay before the Society. Still, however, I think that this map, inaccurate as in many places it may possibly be, will be sufficient to give us a general idea respecting the distribution of seismic activity in this country.

For instance, we see that at the present time a district extending over the Tokio plain and up the Eastern coast

of the Nambu country, is probably one of the most favourable districts for Seismological observations; whilst the district on the West coast from the island of Sado and Niigata to the North into Akita ken, is one of the most unfavourable. Here seismic activity is at a minimum. In the Southern part of Japan, the Island of Shikoku, although many places have from time to time had spasmodic outbursts of seismic action, on the whole is a far more peaceful region than that which surrounds the Capital.

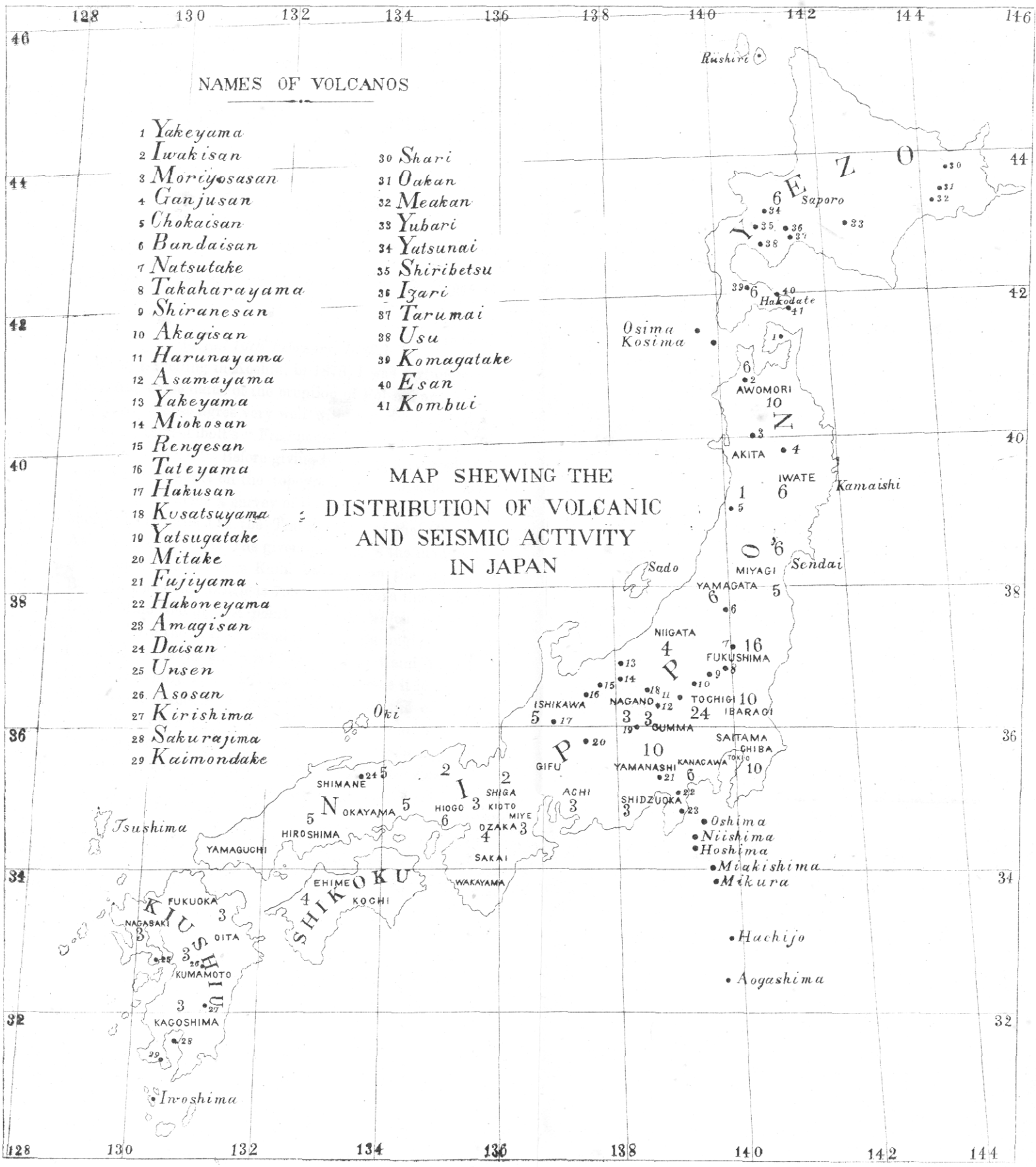
From the records which have been given, it seems that many districts have their local shocks, whilst others extend into surrounding districts. Thus many of the severer shocks which are felt in Kamaishi and Hakodate are also felt in Tokio, which seems to indicate that their origin is somewhere to the North of Tokio, in the ocean and between these places. Another group of shocks extends from Tokio to Niigata and their origin lies between these two places. Many of the Tokio disturbances are of local origin, and in a future communication to this Society I hope to point out so far as I am able, the districts from which they come. With regard to the Seismic activity which is displayed in Japan as a whole, I am at present only enabled to speak in the most general terms.

If from the various records which I have given, we take the average number of earthquakes which are annually felt in the various districts mentioned, we shall find that the sum of their numbers equals about 250; multiplying this by 5, we get 1,250 as the *actual* number of earthquakes which would be recorded if instruments were distributed throughout the country. As the districts from which my records are taken are in many instances far apart, I do not think that we shall over estimate the actual number of *different* earthquakes felt per annum by this number. That is to say, in Japan as a whole, on the average from 3 to 4 earthquakes are felt every day.

Another method of estimating the actual number of earthquakes is as follows. Since the 19th of October to the 31st of December of last year, that is in 73 days without the help of instruments, I have collected together records of over 36 different earthquakes which have been felt in the districts between Tokio and Kamaishi. For the Northern half of this district, however, the records for about 36 days only have been obtained. If records could have been obtained, the number of shocks which I have considered as having been recorded in 73 days would have been considerably increased. If shocks are as numerous during the remainder of the year, then in this portion of Japan we have 180 shocks during the year, and if this portion is one seventh of the whole country, in all Japan we ought to have 1,260 shocks per year, or on an average, between 3 and 4 shocks per day.

Although, in this calculation, I have taken one of the most active districts in Japan and also considered that we have as many shocks in one portion of the year as another, and in this may have obtained results which are too large, there has also been a tendency to make the results too small by considering that *only* 36 shocks were felt in 73 days.

Therefore until we have more accurate records on which to base our calculations, we may with reason consider that in Japan alone, we have every year as many shocks as Prof. Heim calculated for the whole of the globe of which these islands form such a fractional part.



NAMES OF VOLCANOS

- | | |
|----------------|---------------|
| 1 Yakeyama | 30 Shari |
| 2 Iwakisan | 31 Oakan |
| 3 Moriyosasan | 32 Meakan |
| 4 Ganjusan | 33 Yubari |
| 5 Chokaisan | 34 Yatsunai |
| 6 Bandaisan | 35 Shiribetsu |
| 7 Natsutake | 36 Izari |
| 8 Takaharayama | 37 Tarumai |
| 9 Shiranesan | 38 Usu |
| 10 Akagisan | 39 Komagatake |
| 11 Harunayama | 40 Esan |
| 12 Asamayama | 41 Kombui |
| 13 Yakeyama | |
| 14 Miokosan | |
| 15 Rengesan | |
| 16 Tateyama | |
| 17 Hakusan | |
| 18 Kusatsuyama | |
| 19 Yatsugatake | |
| 20 Mitake | |
| 21 Fujiyama | |
| 22 Hakoneyama | |
| 23 Amagisan | |
| 24 Daisan | |
| 25 Unsen | |
| 26 Asosan | |
| 27 Kirishima | |
| 28 Sakurajima | |
| 29 Kaimondake | |

MAP SHEWING THE
DISTRIBUTION OF VOLCANIC
AND SEISMIC ACTIVITY
IN JAPAN

Rushiri

Saporo

Hakodate

Osima
Kosima

AWOMORI

10

AKITA

IWATE

Kamaishi

MIYAGI

Sendai

YAMAGATA

NIIGATA

FUKUSHIMA

ISHIKAWA

NAGANO

TOCHIGI

IBARAGI

SAITAMA

CHIBA

YAMANASHI

KANACAWA

SHIDZUOKA

CHIBA

ACHI

MIYAZAKI

SHIMANE

OKAYAMA

HIROSHIMA

YAMAGUCHI

EHIME

KOCHI

WAKAYAMA

OSIMA

NIISHIMA

HOSHIMA

MIYAKISHIMA

MIKURA

HACHIJU

AGASHIMA

Tsushima

FUKUOKA

NAGASAKI

OITA

KUMAMOTO

KAGOSHIMA

IWOISHIMA

SHIMANE

OKAYAMA

HIROSHIMA

YAMAGUCHI

EHIME

KOCHI

WAKAYAMA

OSIMA

NIISHIMA

HOSHIMA

MIYAKISHIMA

MIKURA

HACHIJU

AGASHIMA