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18. *Study of Historical Earthquakes in Japan.*

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1. Introduction.

It is well known that if we observe a special region in Japan, large earthquakes are rare phenomena, which take place with intervals of more than 100 years. Therefore it is clear that the study of individual historical earthquakes and historical changes of seismicity plays a key role in the long-range prediction of earthquakes and the mitigation of disasters due to large earthquakes. The importance of the study of historical earthquakes has been widely recognized and the study has become one of the subprograms of the earthquake prediction project in Japan.

This article, a brief introduction of the study of historical earthquakes in Japan, was attempted with a desire that the study would be properly understood among seismologists of the world and that the results of the study would be useful for long-range prediction of earthquakes and the study of temporal change in seismicity.

In this article, we investigate earthquakes which took place in and near Japan, that is; Hokkaido including the southern Kuriles, Honshu, Shikoku, Kyushu, Bonin and Ryukyu islands. The word "historical" will be used in this article for the meaning "before 1872". Reasons why the year 1872 was chosen as the year of division are:

1) In this year, instrumental observation of earthquakes started.

2) At the end of this year, the Gregorian calender replaced the Japanese lunar calender. On Nov. 9 of the 5th year of the Meiji Era (1873 Jan. 1st) the Gregorian calender was first put into general use.

3) Documents published after 1873 can be approached more easily than those before 1872 and are printed in type which is more readable to modern Japanese people than those of the historical period.

4) The collection of documents before 1872 is incomplete and a lot of documents have remained untouched. Those documents were written with carbon ink and brush pen and modern Japanese people have difficulty in reading them. Such an old document and the same part printed in type are compared in Fig. 2. Readers can easily recognize that reading the old document is a hard and timeconsuming job and it can never been done without special training.

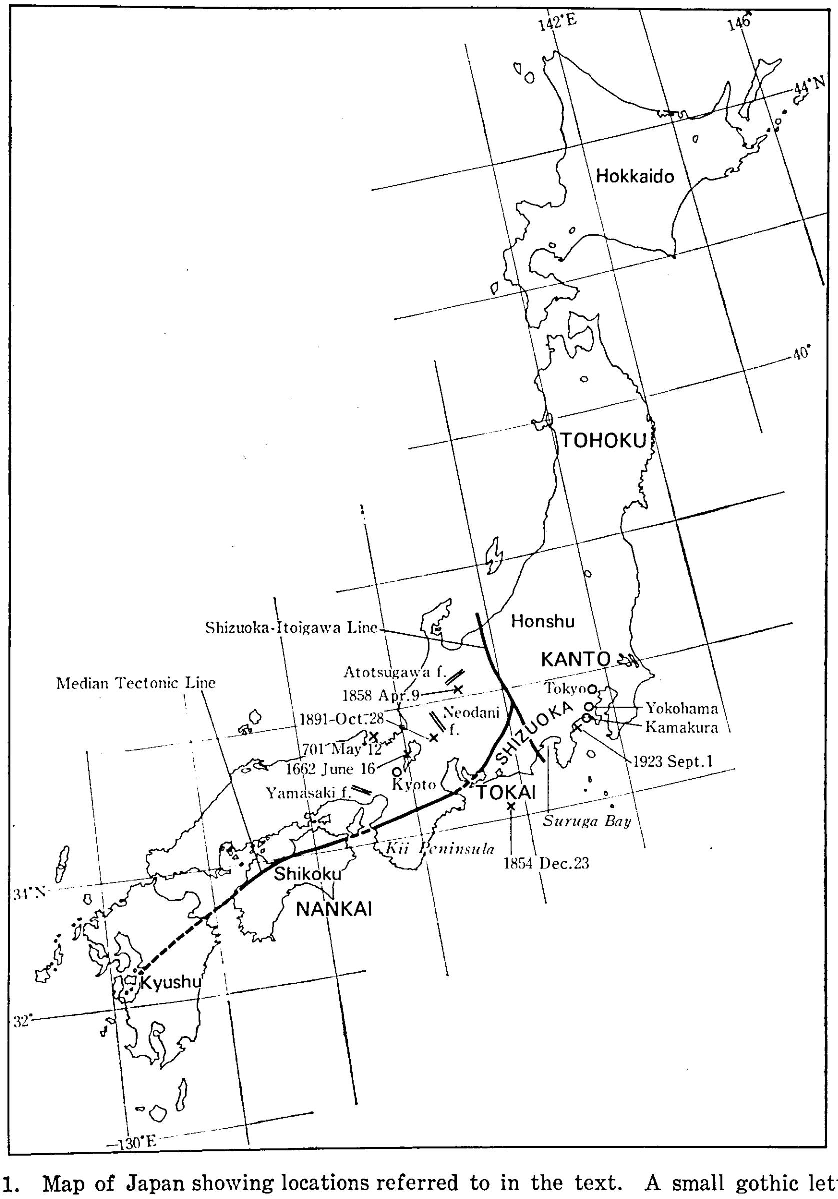

Fig. 1. Map of Japan showing locations referred to in the text. A small gothic letter shows the name of the island, a large gothic letter shows the district name, an open circle the city, a cross the epicenter of the referred earthquake and double lines the fault. Shizuoka is the name of the prefecture.

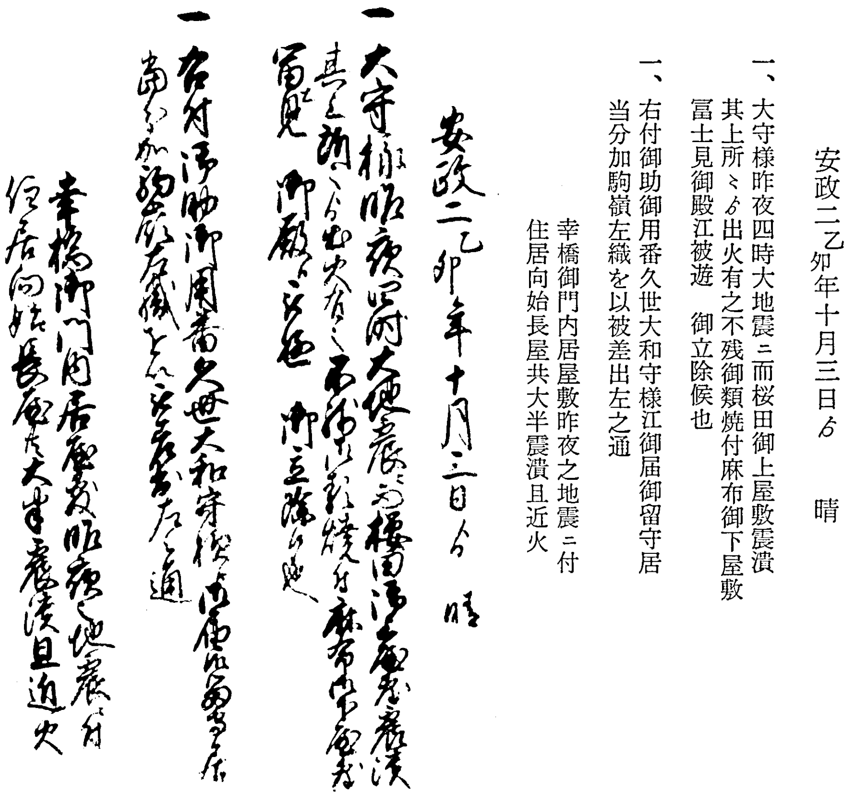

Fig. 2. Comparison of a Japanese old document and corresponding print type.

2. Brief Sketch of the Study of Historical Earthquakes before 1970.

In the historical period, when a disastrous earthquake took place, older earthquakes had usually been referred to and listed for comparison. Considering this kind of work as a study of historical earthquakes, the history of the study can be traced back to before the 10th century. Although those works, incomprehensive lists of big events, could not be said to be scientific, the records included give basic data for modern scientific study of historical earthquakes.

Employing old records including lists of earthquakes as stated above, I. Hattori, Esq. made an extensive study on historical earthquakes in Japan (HATTORI, 1878). Probably this was the first work of its kind in Japan. Thirty-four old documents were employed and 149 destructive earthquakes were found after the 5th century. He gave a short description of each earthquake; summarized the spatial and temporal distributions of disastrous earthquakes; and listed possible forerunning phenomena such as unusual high temperature, unusual change of atmosphere, luminous appearances and magnetic disturbances. Having acknowledged that the 19th century was seismically active, he said that "we have no right to assume that we are to be exempt for the remainder of this century, or during those which are to follow".

In August 1878, Naumann published a paper entitled "Uber Erdbeben und Vulcanausbrueche in Japan" in Mittheilungen der Deutschen Gesellschaft für Natur-und Völkerkunde Ostasiens.

On Feb. 22nd, 1880, a medium earthquake took place near Yokohama ($M = 5.9$). Foreign professors who had been invited to Japan to teach modern science and technology and had lived near Tokyo, were surprised by the event. So, on April 26th of the same year, the Seismological Society of Japan, the first seismological society in the world was established through the efforts of foreign scholars.

In 1881, Milne, one of the invited professors, published a study on historical earthquakes in Japan (MILNE, 1881). He used sixty-four old records including thirty-four used by Hattori and listed 366 earthquakes. His main interest was in examining the seismicity in relation to time and space. One of his findings was that "earthquakes are more frequent in winter than in summer".

From about this time, short introductions concerning specific historical earthquakes were published in various kind of bulletins. On Oct. 28, 1891, the Nobi earthquake ($M = 8.0$) took place in central Japan. The total damage was reported as:

Dead	7,273
Houses totally destroyed	142,177
Houses half destroyed	80,184

The famous Neodani fault appeared in connection to this earthquake. Due to the impact of this event the Imperial Earthquake Investigation Committee was established on June 25, 1892 in order to make investigations for preventing disasters due to earthquakes. One of the eighteen purposes of the Committee set forth at the start was the "investigation of earthquakes in historical ages, that is, the compilation of earthquake history". Tayama was appointed as a partime member of the Committee on July 13, 1893 and was entrusted to execute the compilation of old earthquakes.

About this time, short articles on historical earthquakes were published in various bulletins with increasing number. However, among them the works by Tayama published in 1899 and 1904 were the best and the most fundamental. Tayama had the advantage of being, at the same time, a non-regular member of the Institute for the Compilation of Japanese History. He collected descriptions on earthquakes and tsunamis from old diaries, records, authentic histories, chronicles, and descriptions carved on stone or bronze etc. His first work (TAYAMA, 1899) is a table of 1896 earthquakes (excluding aftershocks) between 416 and 1864 which comprised of the date, locality, magnitude (not instrumental) and references. This work amounts to about 110 pages. His second work (TAYAMA, 1904), perhaps his last work on historical earthquakes, was published in 1904. Its title is "Historical data on Japanese earthquakes" and it consists of two volumes, amounting to 1201 pages altogether. In these volumes descriptions of earthquakes extracted from various kinds of old documents are collected and arranged in chronological order. They include earthquakes from 416 to 1865. This is the first comprehensive and authentic work in the field of historical earthquakes and marked an epoch in the history of the study of historical earthquakes in Japan.

Since Tayama's death, on Nov. 9, 1907, at age 43, the work of collecting old decuments relating to earthquakes has been seemingly inactive. Some seismological studies based on these historical data appeared after Tayama's death. OMORI (1913) picked up ninety-five large earthquakes, estimated their epicenter, shaked area and thus rearranged historical data from the viewpoint of aftershock, tsunami and damage. Thus Tayama's historical data has been changed to a seismologically meaningful one. In 1919, Omori published another work comprising of descriptive tables of historical large earthquakes between 416 and 1918 (OMORI, 1919). Such a table gives seismologically useful information of appropriate length to each earthquake and has become basic for the study of historical earthquakes.

On Sept. 1, 1923, the great Kanto earthquake hit the southern part of the Kanto district including the Tokyo and Yokohama area. The total damage was reported as,

Dead	99,311
Missing	43,467
Houses totally destroyed	128,226
Houses half destroyed	126,233
Houses burnt to ashes	447,128

After that event, much debate had been made on the intensification of earthquake studies and consequently on Nov. 13, 1925, the Imperial Earthquake Investigation Committee was replaced by the Earthquake Research Institute in order to promote more intensive earthquake studies. In 1928, Suyehiro, the first director of the Earthquake Research Institute, asked Musha to revise and enlarge the work by Tayama. Musha was appointed as a non-regular member of the Institute without pay.

In the 1930's and 1940's newly found old documents were fragmentally introduced by several authors on the first series of "Zisin" (in Japanese), with some seismological considerations.

Imamura published several studies on historical earthquakes from the standpoint of earthquake prediction. One of his main conclusion (IMAMURA, 1946) is that a big earthquake may take place in the near future in the Pacific coast of southwestern Japan. He made observations of crustal movements at several points in the Kii peninsula to catch precursory phenomena. However, owing to the shortage of manpower and necessary materials during World War II, he could not continue the observation very long. He wrote a letter to the Academy of Japan on Oct. 12, 1946 expressing his opinion that a large earthquake may hit the Nankai district in the near future and suggesting that the greatest attention should be made toward mitigating disasters due to the earthquake. The anticipated earthquake took place on Dec. 7, 1946, giving damage totalling to:

Dead and missing	1,432
Houses totally destroyed	11,591
Houses half destroyed	23,487
Houses washed away	1,451
Houses burnt to ashes	2,598

Thus unfortunately, Imamura's fear came true. He died on Jan. 1, 1948 in obscurity.

Musha was a high school teacher who spent most of his leisure time collecting old documents. After thirteen years of effort, he published in 1942 the first volume of the revised edition of "Historical data on Japanese earthquakes".

The second and third volumes were published in 1943 (MUSHA, 1942–1943). These three volumes are mimeographed. The fourth volume (MUSHA, 1949) was published in 1949 in type. The four volumes amount to 4000 pages in all and include 6000 earthquakes (excluding aftershocks) between 416 and 1867. In writing them, Musha paid attention to:

a) Correcting errors in Tayama's edition and in "History of Japanese eruption" compiled by OMORI (1918).

b) Reinvestigating literature employed in the above two reports and making corrections and additions.

c) Collecting records on earthquakes from old documents not used in the above two reports.

d) Looking for local documents, such as local histories, diaries etc.

e) Looking for records on earthquakes, written by foreigners.

f) Looking for records on earthquakes in Korea and Formosa.

g) Collecting records of phenomena related to earthquakes and eruptions, such as ash fall, abnormal luminous phenomena of sun and moon, rumbling, landslides, or unusual behavior of underground water and tides.

h) Collecting records implicitly suggesting earthquakes, volcanic eruptions or landslides.

i) Collecting legends and traditions.

The revised edition by Musha is too voluminous to read through. He picked up large disastrous earthquakes from them, gave appropriate summaries for each event and arranged them in a report entitled "Chronological table of large earthquakes in and near Japan" (MUSHA, 1950-1953). This report was mimeographed too. Since then the importance of such a chronological table has become to be acknowledged among seismologists. The first seismologist who recognised the importance of this table, gave life to the old data and made it important to modern seismology was the late Dr. H. Kawasumi. He estimated magnitude and epicenter location for destructive historical earthquakes and his efforts resulted in two works.

a) Sixty-nine year periodicity of strong earthquakes in the southern Kanto district (KAWASUMI, 1963). In Kamakura the number of earthquakes with intensity of more than V changes with period of 69 years. About two-thirds of such earthquakes occur during 27 years before and after the peak time which comes in every 69 years.

b) The so-called Kawasumi's map (KAWASUMI, 1952) showing maximum acceleration anticipated in every 75, 100 and 200 years. This map gave a reliable basis for earthquake-proof design of buildings and was referred to for the revision of building codes.

In this way, after 60 years since the establishment of the Imperial Earthquake Investigation Committee, the study of historical earthquakes has become to be applied to practical problems, such as earthquake-proof engineering, which was a goal set forth at the start of the Committee.

3. Short Summary of the Study of Historical Change of Seismicity.

Preliminary studies summarising the historical change of seismicity based on "historical data" were done by the present author. Figure 3 shows the change in the annual number of earthquakes in Japan, excluding aftershocks. The solid part indicates destructive earthquakes and the open part the felt ones without damage. Figure 4 shows the annual number of earthquakes felt at Yedo (expressed as

ANNUAL NUMBER OF FELT EARTHQUAKES IN JAPAN
(416~1867)

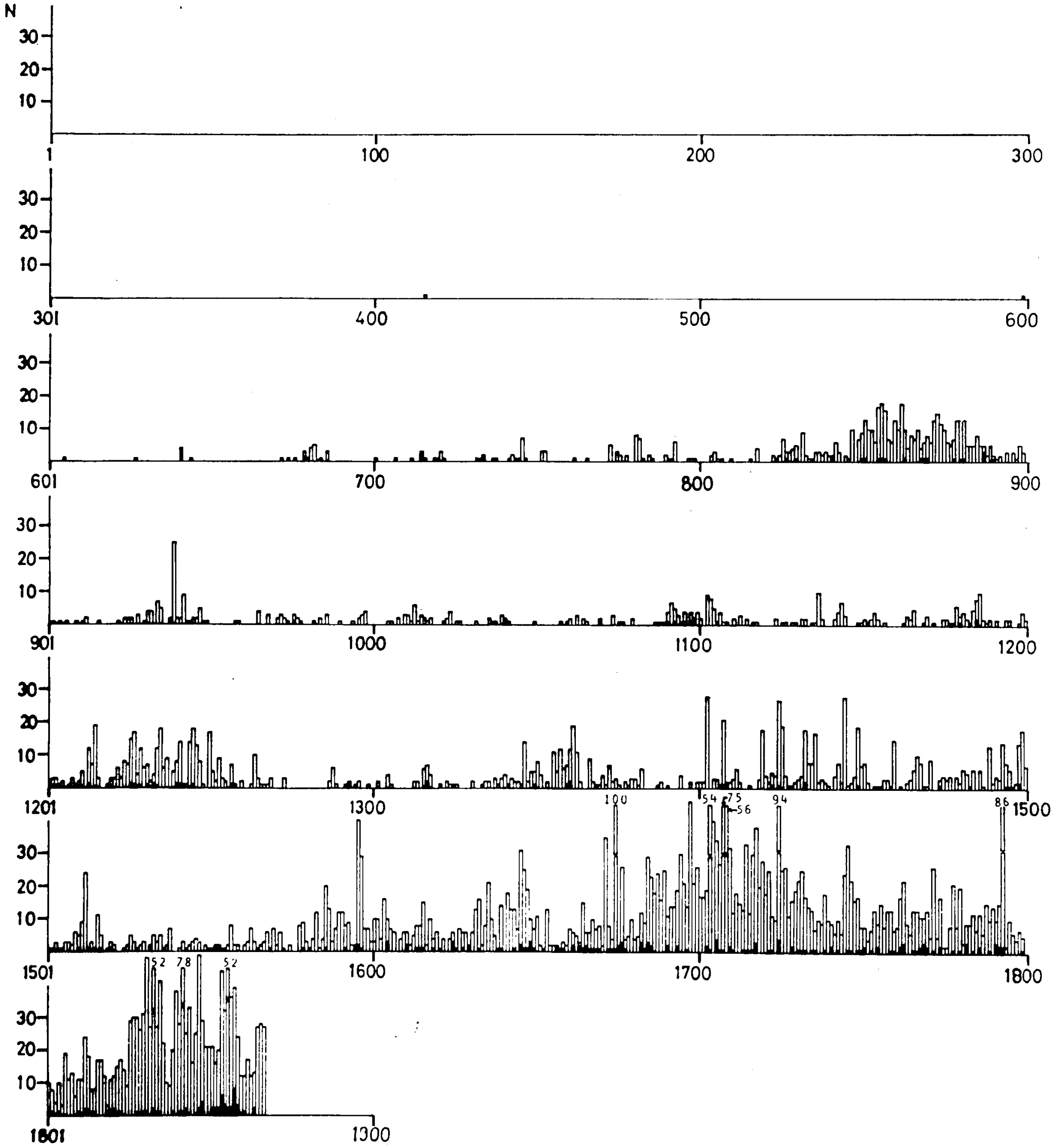

Fig. 3. Annual number of earthquakes in historical time. Aftershocks are excluded. Solid part shows earthquakes with damage.

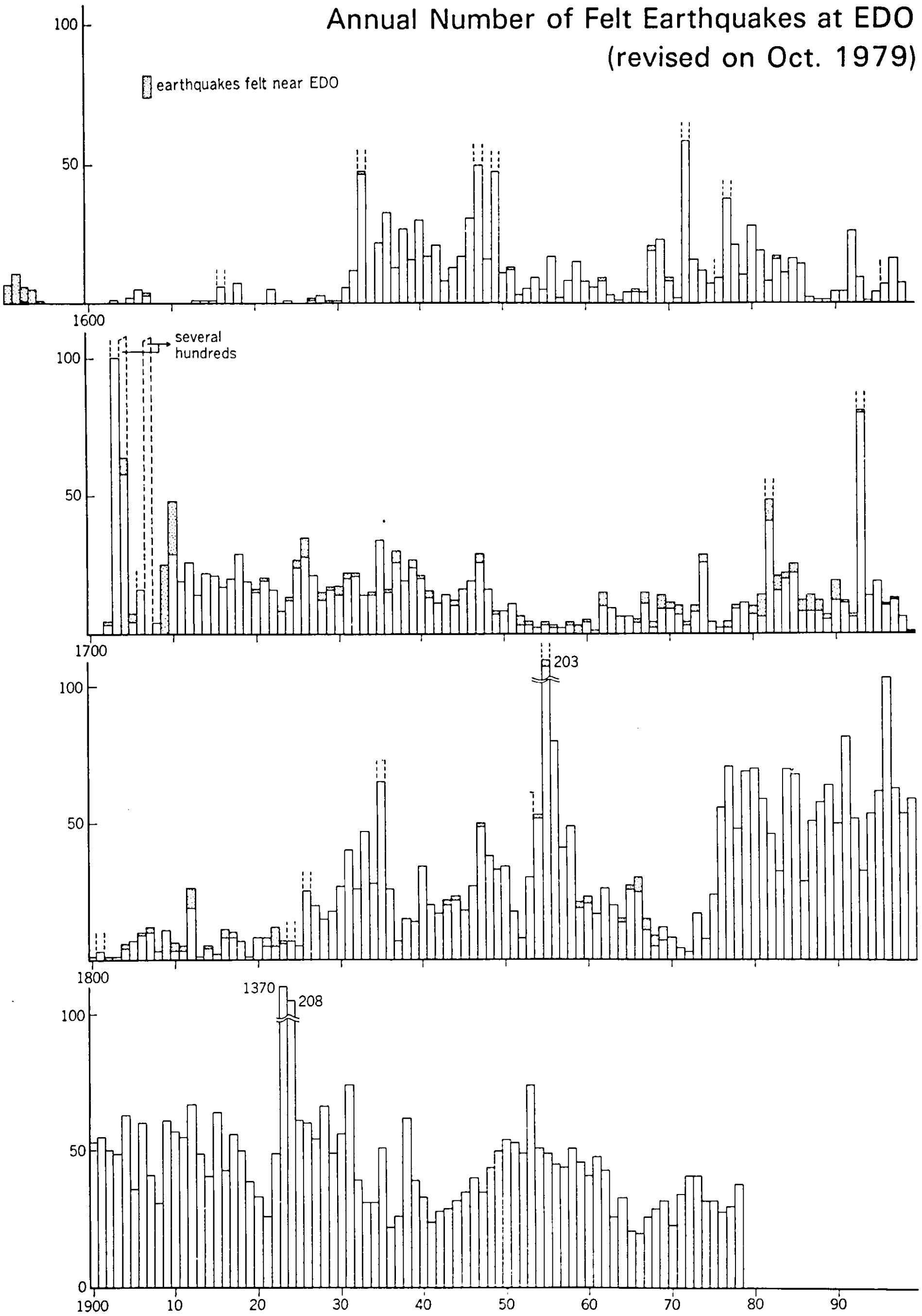

Fig. 4. Annual number of felt earthquakes at Tokyo (Yedo). Aftershocks are included. Dotted part means earthquake not felt at Yedo, but felt in the vicinity of Yedo.

Edo in figures) (USAMI, 1976), the former name of Tokyo, from 1590 to 1978. Numbers between 1876 and 1896 were estimated from data observed by J.M.A (Japan Meteorological Agency). During this period, observations by J.M.A. were not complete compared with those after 1897. After 1897 numbers observed at Tokyo by J.M.A. are displayed. The dotted part at the top of some columns means that the annual number is more than that.

Looking at these two figures, one can easily find out pseudo-periodic change of seismic activity. However, before we deduce a conclusion, we have to consider the validity and completeness of the "historical data". In these days, the annual number of earthquakes felt in Japan is about 1000 and those felt at Tokyo is about 30. Comparing these numbers with those in Figs. 3 and 4, we can conclude that the "historical data" is incomplete. This incompleteness is due to both the lack of old documents and the insufficient collection of them. The first job we should do before we try to get a definite conclusion about the change of seismicity in historical time, is the collection of hidden documents.

The present author (1977) made a descriptive table of destructive earthquakes in Japan. The number of such earthquakes is 617 between 416 and 1975. Of them 282 earthquakes took place in historical time. Spatial distributions of epicenters are shown in Figs. 5 and 6 and the number of destructive earthquakes in every ten years is given in Fig. 7. Solid, hatched and dotted parts indicate those at Kyoto, Kamakura, and Yedo respectively. Kamakura became the capital of Japan at the beginning of the 13th century and Yedo at the beginning of the 17th century. Figure 7 shows that disastrous earthquakes in the vicinity of the capital increases suddenly at the time of the opening of a new government.

Table 1 shows a list of destructive earthquakes. It is made from table by USAMI (1977) and it includes event number, date and time, epicenter location, depth, magnitude, magnitude of tsunami, grade of damage, number of the dead and of totally destroyed houses (by fire, tsunami and vibration). The Gregorian calender is employed.

Magnitude and epicenter location of earthquakes before 1884 were taken from Kawasumi's work. He derived magnitude using the relation

$$M = 0.5M_k + 4.85$$

where M_k is the Japanese intensity scale at a point 100 km distance from the epicenter. For earthquakes after 1926, magnitude and epicenter determined by J.M.A. were adopted. For those between 1885 and 1925, values given by UTSU (1979) were adopted. However, for

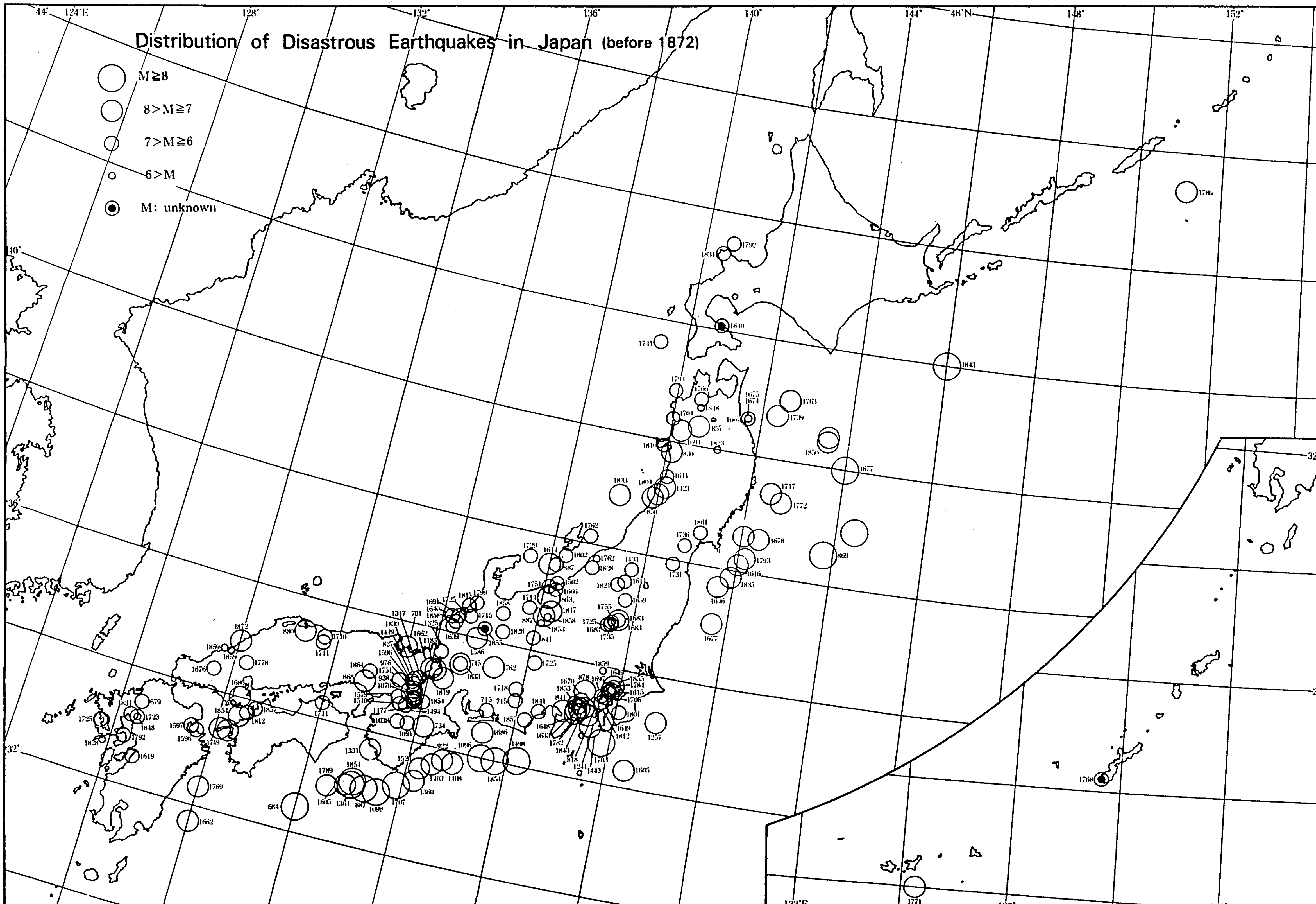

Fig. 5. Distribution of disastrous earthquakes in Japan (before 1872).

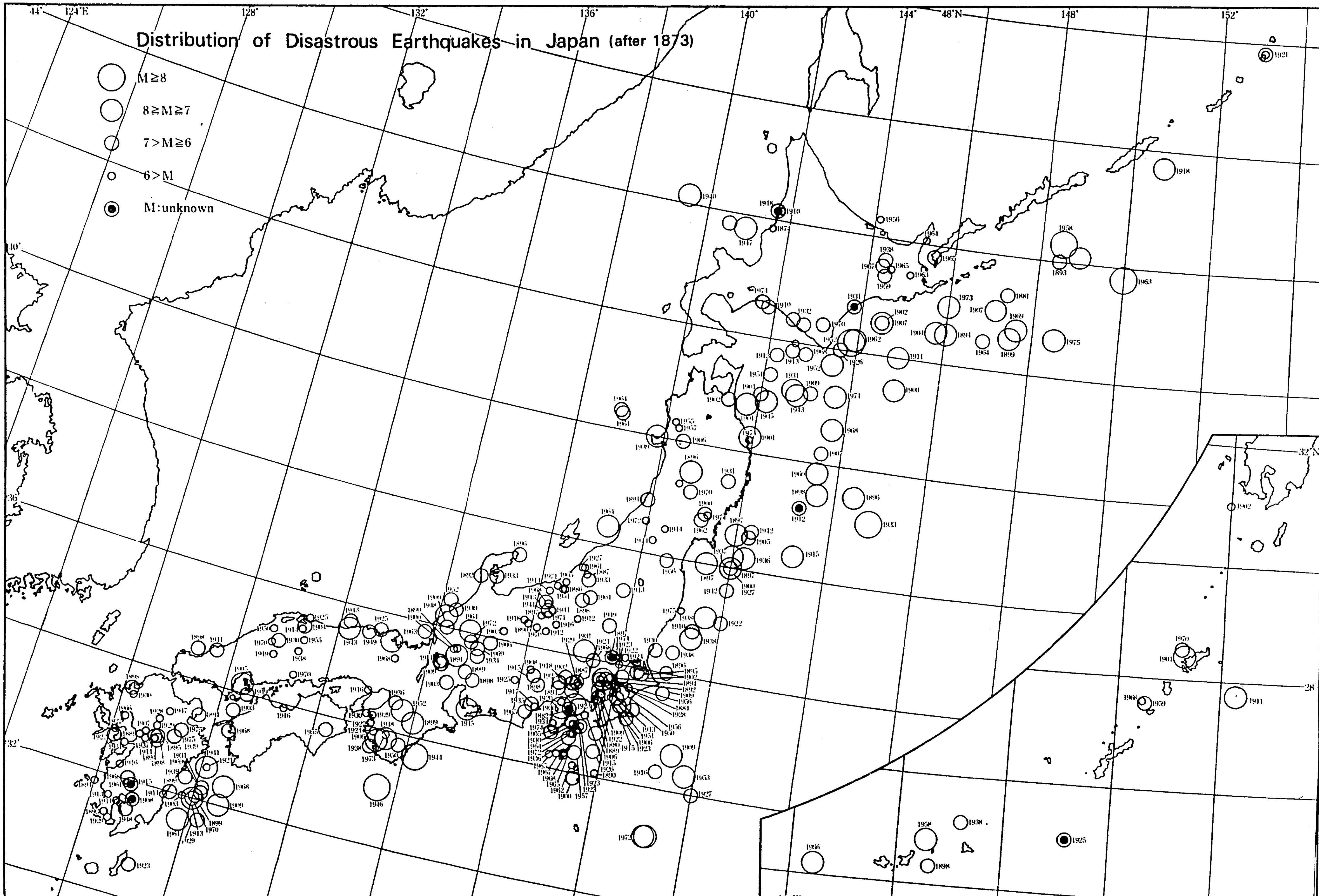

Fig. 6. Distribution of disastrous earthquakes in Japan (1873 and later). Number beside circle shows occurrence year of each event. For earthquakes between 1885 and 1925 inclusive, epicenters in Table 1 are correct.

Table 1. List of earthquakes with damage in Japan before 1975. Earthquakes accompanied by damage to human life or buildings are adopted. Those with slight damage such as things falling off shelves, collapse of stone-lanterns or weak fences are excluded. The Gregorian calender is adopted. Columns of month, day and time are blank when they are not known. The letter "*m*" indicates the magnitude of tsunami (see text). Square brackets [ ] indicate the grade of damage (see text). In the ninth and tenth columns, an open circle is used when the dead or the building destroyed is undoubtedly acknowledged, but their number is unknown. In the tenth column, damage due to ground motion, tsunami, fire, and landslides to all kinds of building are included. J.S.T. is adopted.

Event No.	Date and time		Epicenter		Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
			λ(°E)	φ(°N)							
1	$599^y5^m28^d$					7.0		I		○	
2	679	night	130.5	33.5		6.7		I		many	
3	684 11 29		134.0	32.5		8.4	3	IV	many	many	Tsunami, cf. Table 6
4	701 5 12		135.4	35.7		7.0	2	II			
5	715 7 4		137.9	35.1		6.4		0		○	Land slide choked up river
6	715 7 5		137.4	34.8		6.7		I		≧47	
7	734 5 18		136.1	34.3		7.0		II		many	First luminous phenomena in Japan
8	745 6 5		136.6	35.5		7.9		IV		many	
9	762 6 9		137.3	35.6		7.4		III			
10	799 9 18										Tsunami hit east coast of Kwanto
11	818		139.3	35.2		7.9	1	IV	many	○	Landslide, Tsunami(?)
12	827 8 11		135.75	35.0		6.7		I		many	Many aftershocks observed
13	830 2 3	$05\text{-}07^h$	140.1	39.8		7.4		III	15	○	
14	841		138.0	36.2		6.7		I		few	
15	841		138.9	35.1		7.0		II	○	○	
16	850		139.9	39.0		7.0	2	II	many	○	Landslide, fissures
17	856					6.4		0		○	
18	857 4 4		140.6	40.3		7.0		II		○	Landslide
19	863 7 10		138.1	37.1		7.0		II	many	○	Landslide
20	868 8 3		134.8	34.8		7.1		II		many	
21	869 7 13	night	143.8	38.5		8.6		IV	1,000	many	Tsunami, Luminous phenomena
22	878 11 1	night	139.3	35.5		7.4		II	many	many	
23	880 11 23		133.2	35.4		7.4		I		many	
24	881 1 13	00				6.4		0		many	
25	887 8 2	night	138.1	37.5		6.5	2	II	several 1,000		Tsunami
26	887 8 26	15-17	135.3	33.0		8.6	3	IV	many	many	Tsunami
27	887 8 26		138.1	36.6		7.4		III	many		Landslide
28	890 7 10	05-07				6.2		0			Kyoto

Table 1 (Continued)

Event No.	Date and time				Epicenter λ(°E)	φ(°N)	Depth (km)	*M*	*m*	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
29	922				136.7	33.8		7.0	1	II			Tsunami
30	934	7	16	12				6.2		0			Kyoto
31	938	5	22	19-23	135.8	34.8		6.9		I	4	many	
32	976	7	22	15-17	135.8	34.9		6.7		I	≧50	many	
33	1038	1	30		135.6	34.3		6.7		I		many	
34	1041	8	25	01-03				6.4		0		○	Kyoto
35	1070	12	1	mid-night	135.8	34.8		6.4					Kyoto
36	1091	9	28	15-17	135.8	34.3		6.2		0		○	
37	1093	3	19	13-15				6.4		0			Kyoto
38	1096	12	17	07-09	137.5	34.0		8.4	2	III		many	Tsunami hit eastern coast of Japan
39	1099	2	22	05-07	135.5	33.0		8.0		IV			cf. Table 6
40	1099	9	20					6.4		0		○	Near Osaka
41	1177	11	26	01-03	135.8	34.7		6.2					
42	1185	8	13	11-13	136.1	35.3		7.4		III	many	many	Many after-shock
43	1213	6	18					6.4		0		○	Landslide, Kamakura
44	1227	4	1	19-21				6.2		0		○	Fissure, Kamakura
45	1240	3	24	05-07				6.4		0		○	Landslide, Kamakura
46	1241	5	22	19-21	139.4	35.1		7.0	1	II		○	Tsunami hit Kamakura
47	1245	8	27	01-03				6.2		0		○	Kyoto
48	1257	10	9	19-21	140.9	35.2		7.0	1	II		many	Many after-shock, Fissure
49	1293	5	27	05-07				7.1		II	Several ×1,000	many	Kamakura
50	1317	2	24	03-05	135.8	35.1		6.7		I	5	many	Many after-shock
51	1325	12	5	21-23	136.1	35.6		6.7		I		○	Landslide
52	1331	8	15		135.2	33.7		7.0		II			Upheaval of coast of Kii peninsula
53	1350	7	6	15-17				6.2					Kyoto
54	1360	11	22		136.2	33.4		7.0	2	II	many		Tsunami hit Kii
55	1361	8	1	05-07									Foreshock of No. 56?
56	1361	8	3	03-05	135.0	33.0		8.4	3	IV	≧60	many ≧1,700	Tsunami hit s-w Japan
57	1369	9	7					6.1		0			Kyoto
58	1403				136.5	33.7		7.0	1	II			Tsunami
59	1408	1	21		136.9	33.8		7.0	1	II			Hot spring stopped for 80 days
60	1423	11	23	07-09	140.1	39.2		6.7		I	many	many	
61	1425	12	23	09-11									Kyoto
62	1433	11	6	00	139.5	34.9		7.1	1	II		○	River Tone flew upward Landslide

Table 1 (Continued)

Event No.	Date and time				Epicenter λ(°E)	φ(°N)	Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
63	1433	11	6		139.8	37.7		6.7		I		many	
64	1449	5	13	07-09	135.75	35.0		6.4		0	many	○	
65	1456	2	14	night						I		○	Kii
66	1466	5	29	17-21									Kyoto
67	1494	6	19	11-13	135.7	34.6		6.4		I			
68	1498	9	20	07-09	138.2	34.1		8.6	3	IV	≧10,000	Several ×1,000	Big Tsunami hit eastern coast of Japan
69	1502	1	28	06-11	138.2	37.2		6.9		I	many	many	
70	1510	9	21	03-05	135.6	34.6		6.7	1	I	○	○	High tide
71	1517	7	18					6.4		0		many	Echigo
72	1520	4	4	15-19	136.3	33.6		7.0	1	II		○	Tsunami hit Kii
73	1525	9	20										Kamakura
74	1543			night							○	many	Hiroshima area
75	1552												Kii
76	1555	9	14					6.7				○	Aizu
77	1579	2	25	09-11	135.5	34.7		6.2					Osaka area
78	1586	1	18	23	136.8	36.0		8.1		IV	≧300	many	Landslide buried a castle
79	1589	3	21		138.2	34.8		6.7		I		○	
80	1592	10	8	10				6.7					Chiba
81	1596	9	4	15-21	131.7	33.3		6.9	2	II	≧700	many	Foreshock, Landslide
82	1596	9	5	00	135.75	34.85		7.25		II	≧1,100	many	Many after-shock
83	1597	9	10		131.6	33.3		6.4			≧40	≧70	Big landslide
84	1605	2	3	19-21	{140.4 {134.9	34.3 33.0		7.9	3	IV	Several ×1,000	many	Double earthq., Tsunami hit central and western Japan
85	1611	9	27	09	139.7	37.5		6.9		III	≧3,700	≧20,000	New lake ap-peared
86	1611	12	2	after 09	144.5	39.0		8.1	4	IV	Several ×1,000	many	Tsunami hit n.-e. Japan
87	1614	11	26	13	138.0	37.5		7.7	2	III	many	○	
88	1615	6	26		139.7	35.7		6.4		0	○	○	
89	1616	9	9	15	142.0	38.1		7.0	1	II	○	○	Tsunami
90	1618	9	30										Kyoto
91	1619	5	1	12	130.6	32.5		6.2				○	
92	1625	1	21									○	Hiroshima
93	1625	7	21										Kumamoto
94	1628	8	10					6.1					Tokyo
95	1630	8	2	00				6.7					Tokyo
96	1633	3	1	05	139.2	35.2		7.1	1	II	≧150	many	
97	1635	3	12	13				6.1					Tokyo
98	1639				136.2	36.1		6.1					
99	1640	11	23		136.2	36.4		6.7		I	○	○	
100	1643	12	7	morning				6.2					Tokyo
101	1644							5.9					Nikko

Table 1 (Continued)

Event No.	Date and time	Epicenter λ(°E)	Epicenter φ(°N)	Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
102	1644 10 18	140.1	39.4		6.9		0	○	○	
103	1646 6 9	141.7	37.7		7.6		III			
104	1647 6 16				6.4		0	○		Tokyo
105	1647 9 3 dawn									Tokyo
106	1648 6 13	139.2	35.2		7.1		I		many	
107	1649 3 17	132.4	33.7		6.8		II		○	
108	1649 7 30 01-03	139.75	35.7		7.1		II	○	○	
109	1649 9 1 13	139.7	35.5		6.4		I		≧150	
110	1650 4 24 04-05				6.6					Tokyo, Nikko
111	1657 1 3 night									Nagasaki
112	1658 5 5 night				6.2					Nikko
113	1659 4 21	139.8	37.2		6.7		I	39	400	
114	1661 12 10				6.1					Kochi
115	1662 6 16 11-13	136.0	35.25		7.8		III	≧800	≧4,000	Landslide
116	1662 10 31 00	132.0	31.7		7.6	2	III	>20	>3,400	Tsunami hit e. coast of Kyushu
117	1664 1 4 19-21				5.9					Kyoto
118	1664 8 3				6.6					Kii
119	1664					1		1		Under-sea eruption
120	1665 6 25				6.1					Kyoto
121	1666 2 1	138.2	37.1		6.4		I	1,500	>700	
122	1667					1				Okinawa
123	1667 8 22 09-11	141.6	40.6		6.4					
124	1668 8 28 16-17				5.9					Sendai
125	1669 6 29				5.9					Nagoya
126	1670 7 21	139.2	35.4		6.4				>100	
127	1674 4 15	141.6	40.6		5.9					
128	1675 4 4 morning	141.6	40.6		5.9					
129	1676 7 12	131.7	34.4		6.6		I	7	133	
130	1677 4 13 19-21	144.0	40.0		8.1	2	II			Tsunami hit n.-e. Japan
131	1677 11 4 17-19	141.5	37.0		7.4	3	III	>480	>900	Tsunami hit e. coast of Kwanto
132	1678 10 2 17-19	142.3	38.6		7.4		II	1	20	
133	1683 6 17 08	139.6	36.7		6.4		0			Many fore-shoks and aftershocks
134	1683 6 18	139.65	36.75		7.3		I			Many after-shocks
135	1683 10 20	139.7	36.8		6.8		0			Landslide choked up rivers, Many aftershocks
136	1684 12 22									Hiuga
137	1685				6.4		0	○	○	Landslide
138	1685 10 7 11-13									Yamaguchi
139	1685 12 29				5.9					Iyo

Table 1 (Continued)

Event No.	Date and time	Epicenter λ(°E)	φ(°N)	Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
140	1686 1 4	132.3	34.0		7.0		I	○	many	
141	1686 10 3 07-11	137.4	34.45		7.0		I	○		
142	1687 10 22					0				Tsunami due to earthq. off Peru
143	1691	136.3	36.3		6.2		I		○	
144	1694 6 19 06-07	140.2	40.2		7.0		II	394	2,312	
145	1694 12 12				6.1					Tango
146	1696 6 1									Okinawa
147	1697 11 25 12-13	139.6	35.5		6.9		I		○	
148	1698 10 31 15-16									Miyazaki
149	1703 12 31 01-03	139.8	34.7		8.2	3	IV	≧5,233	≧20,162	Tsunami hit s. Kanto, upheaval of coast ≒4m
150	1704 5 27 12-13	140.0	40.4		6.8		II	50-100	1,500	Many aftershocks, Upheaval of coast ≒2m
151	1706								○	Okinawa
152	1706 10 21 22	139.8	35.6		6.6					
153	1707 10 28 13-14	135.9	33.2		8.4	4	IV	>5,000	>20,000	Tsunami hit s.-e. Japan. Biggest earthq. in Japan
154	1708 2 13					1				Aftershock of No. 153
155	1710 9 13 18				6.4		0		○	Aizu
156	1710 10 3 13-15	133.7	35.4		6.6		I	many	>60	
157	1711 3 19 23	133.7	35.3		6.6		I	4	>500	
158	1711 12 20 14	134.0	34.3		6.7	1	I	>1,000	1,713	
159	1714 4 28 21-23	137.8	36.7		6.4		0	100	several ×100	
160	1715 2 1	136.6	35.4		6.2					
161	1717 5 13	142.4	39.4		7.6		III			
162	1718 2 26				6.2					Hachinohe
163	1718 8 22 13-15	137.9	35.3		6.4		I	>50	○	Landslide
164	1718 10 5	138.4	36.9		6.2					
165	1722 9 24							○	○	Tsunami hit Kii-Owari
166	1723 12 18 08-09	130.4	33.2		6.2				○	
167	1725 5 29 14-15	139.6	36.75		6.6		0			
168	1725 6 17	136.4	36.4		5.9					
169	1725 8 14 13-15	138.1	35.8		6.1					
170	1725 11 8, 9	129.8	33.0		6.2					Many aftershocks
171	1729 3 8 11-13									Izu Fissure
172	1729 8 1 13-15	137.6	37.6		6.9		I	>5	>835	Landslide 1,731
173	1730 7 9					1				Tsunami due

Table 1 (Continued)

Event No.	Date and time	Epicenter λ(°E)	Epicenter φ(°N)	Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
										to earthq. off Chile
174	1731 10 7	140.6	37.9		6.6		I		>300	
175	1732 12 21				6.2					Tsugaru
176	1733 9 18 13-14				6.6		I			Aki
177	1735 4 6 10-11	139.6	36.75		5.9					
178	1736 4 30	140.8	38.3		6.2					
179	1739 8 16	142.3	40.7		7.1		II		○	
180	1741 8 28	139.4	41.6		6.9	3		>1,475	≧873	Tsunami due to eruption
181	1743 8 7 09-11									Hachinohe
182	1746 5 14 19-20				6.9		II			Tokyo, Nikko
183	1749 5 25 10-11	132.6	33.2		6.75		II			
184	1751 3 26 13-15	135.4	35.0		6.4					
185	1751 5 20 01-03	138.1	37.1		6.6		II	>2,100	>5,800	Landslide buried village
186	1753 2 11 01-03									Kyoto
187	1755 3 29 evening				6.2					Mutsu
188	1755 4 21 14	139.6	36.75		6.2					
189	1760 5 15 01-03								○	Okinawa
190	1762 3 29 11-12	139.0	37.8		5.9		I			
191	1762 10 31 14	138.7	38.1		6.6	1	II	○	>26	
192	1763 1 29 18	142.5	41.0		7.4	1	III		○	Many foreshocks
193	1763 3 11	143.5	40.5		7.75		III		○	
194	1763 3 15				7.1	1	II	○	○	
195	1766 3 8 17-19	140.6	40.8		6.9		II	>1,700	>8,200	
196	1767 5 4 09								>21	Rikuchu
197	1768 7 22 11	127.5	26.2			1				Okinawa
197	1768 9 8				5.9					Hachinohe
199	1769 7 22				5.9					Hachinohe
200	1769 8 29 14	132.0	32.3		7.4	1	II			
201	1770 5 27 06?	142.0	38.6		7.4		III	many		
202	1771 4 24 07-09	124.3	24.0		7.4	4	III	9,313	2,176	Ishigaki is washed by tsunami
203	1772 6 3 09-11	142.7	39.3		7.4		III	○	○	
204	1774 1 22 22-23									Tango
205	1778 2 14 05-07	132.7	34.6		6.6		I			
206	1780 5 31	151.2	45.3		7.0	1	II	4		Itrup island hit by tsunami
207	1782 8 23 01-03 21-23	139.2	35.2		7.3	1	I	○	>1,000	Landslide
208	1782 9 21 09-11				6.1					Hachinohe
209	1784 8 29	139.8	35.6		6.1					
210	1786 3 23									Swarm at Hakone
211	1789 5 10 00	134.5	32.9		7.4		III			
212	1791 1 1 night									Tokyo

Table 1 (Continued)

Event No.	Date and time	Epicenter λ(°E)	Epicenter (φ°N)	Depth (km)	*M*	*m*	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
213	1792 5 21 18^h	130.3	32.8		6.4	3		15,030	>6,200	Volcano slided into the sea causing high tsunami
214	1792 6 13 15-17	140.6	43.5		6.9	2		>5		
215	1793 1 13								○	Nagato, Suho
216	1793 2 8 13-15	139.95	40.85		6.9	1	II	12	>175	Upheaval of coast ≒3.5*m*
217	1793 2 17 09-11	142.1	38.25		7.1	2	IV	≧25	many	Tsunami hit n.-e. Japan
218	1799 6 29 16	136.6	36.6		6.4		I	15	1,000	
219	1801 5 26	140.1	35.3		6.5				○	Details unknown
220	1801 11 27 03-05?									Ohmi
221	1802 11 15 night									Ohmi
222	1802 12 9 09-11 13-15	138.3	37.7		6.6		II	37	1,500	
223	1804 7 10 21-23	139.95	39.05		7.1	1	II	450	10,000	A lake upheaved and became paddy field
224	1810 9 25 15	139.9	39.9		6.6	1	I	59	>1,000	
225	1812 4 21 19	132.5	33.8		6.9		II			
226	1812 12 7 15	139.65	35.45		6.6		I	○	○	
227	1814 11 22 17				6.2					Kochi
228	1815 3 1 23	136.5	36.4		6.[illegible]		0			Details unknown
229	1819 8 2	136.3	35.2		7.4		I	>70	>600	
230	1821 9 12 12				5.9			1		
231	1821 12 13 09	139.5	37.4		6.1		I	○	130	
232	1823 10 23	141.1	40.0		5.9			○	○	Mt. Iwate erupted, Land slide
233	1826 8 28 11	137.3	36.2		6.2				○	
234	1828 5 26 night	129.9	32.6		5.9				○	Coal mine crashed
235	1828 12 18 07	138.9	37.6		6.9		II	1,443	9,808	Quick sand phenomena appeared
236	1830 8 19 15-17	135.7	35.0		6.4		I	>285	many	
237	1831 11 14 01-03	130.3	33.2		6.1		I		○	
238	1833 5 27 13	136.6	35.5		6.4		I	○		
239	1833 12 7 15	139.15	38.9		7.4	2	II	85	>879	Tsunami hit Japan Sea coast of n.-e. Japan
240	1834 2 9 10	141.4	43.3		6.4		I		>23	
241	1835 7 20 13-15	141.9	37.9		7.6	2	0			Details unknown
242	1839 5 1 13-15				7.3					
243	1841 4 22 13-15	138.5	35.0		6.4		0			
244	1842 4 17									Okinawa. Swarm

Table 1 (Continued)

Event No.	Date and time	Epicenter λ(°E)	Epicenter φ(°N)	Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
										earthq.
245	1843 3 9 11	139.2	35.25		6.3		I			
246	1843 4 25 06	146.0	42.0		8.4	2	III	46	75	Tsunami height 4.5m at eastern Hokkaido
247	1844 8 8								○	Higo
248	1847 5 8 21	138.2	36.7		7.4		III	>6,000	>14,000	Landslide choked up river which flooded afterwards
249	1847 5 13 12				6.5			many	many	
250	1848 1 10	130.4	33.2		5.9				○	
251	1848 1 13 03	140.6	40.7		5.9				○	
252	1853 1 26	138.1	36.5		5.9				3	
253	1853 3 11 10	139.1	35.3		6.5		I	24	1,032	
254	1854 7 9 01-03	136.0	34.75		7.6		II	1,800	>4,300	Many aftershocks
255	1854 7 27									Rikuzen
256	1854 10 11							>70	○	Ise
257	1854 12 23 09	137.8	34.0		8.4	3	IV	Several ×1,000	>10,000	Tsunami hit Tokai area
258	1854 12 24 16	135.0	33.0		8.4	4	IV	3,000	>30,000	Tsunami hit s.-w. Japan
259	1854 12 26 10	132.1	33.4		7.0		II		>100	
260	1855 3 18 14	136.9	36.2				0	12	2	
261	1855 8 6									Kizuki
262	1855 11 11 22	139.8	35.65		6.9		II	10,000	>17,000	Tokyo
263	1856 8 23 13	143.5	40.5		7.75	2	IV	≧26	≧100	
264	1856 11 4 09				6.6		0			Tokyo
265	1857 7 14 07-09	138.2	34.8		6.4		0			
266	1857 10 12 08	132.7	33.9		6.9		I	1	3	
267	1858 2 3 09-11									Kumamoto
268	1858 4 9 01	137.2	36.5		6.8		III	>380	>2,000	Mountain slide choked up rivers. Flooded afterwards
269	1858 4 9 03-05	136.3	36.2		6.9		II		>200	
270	1858 4 9 15-17						0			Tango. Fissure
271	1858 4 23 08	138.2	36.6		5.9		I		○	
272	1858 5 17								3-4	Suwa
273	1858 8 24									Kii
274	1858 9 29 09								○	Aomori
275	1859 1 5 17-19	131.8	34.7		5.9		0		>10	Landslide
276	1859	139.7	35.9		5.9		0			
277	1859 10 4	131.9	34.7		5.9		0		○	Landslide
278	1861 10 21 03-05	141.1	38.55		6.4	2	III	○	>60	Tsunami hit n.-e. Japan
279	1864 3 6 01	134.8	35.0		6.4				○	

Table 1 (Continued)

Event No.	Date and time	Epicenter λ(°E)	Epicenter φ(°N)	Depth (km)	*M*	*m*	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
280	1864 3 29									Rikuchu
281	1869 3 18									Aki
282	1872 3 14 17	132.0	34.9		7.1	0	II	>800	>5,700	Sea receded before the event
283	1874 2 28	141.6	43.9		5.9					
284	1880 2 22 00 50	139.75	35.4		5.9					
285	1881 10 25 21 22	147.3	43.3		6.5				○	
286	1882 6 24 11 02									Kochi
287	1882 9 29 05	139°05′	35°07′							
288	1884 10 15 04 21	139.75	35.7							
289	1886 7 23 00 57	138.5	37.1		5.3				2	
290	1887 1 15 18 51	139.3	35.5		6.2					
291	1887 7 22 20 27	138.9	37.5		5.7				○	
293	1888 4 29 10 00	140.0	36.6		6.0					Tochigi
292	1889 2 18 06 09	139.7	35.5		6.0					
294	1889 5 12 10 42	136.8	35.4		5.9					
295	1889 7 28 23 45	130.7	32.8		6.3			20	320	
296	1889 10 1 01 50	130	28		6					Amami-Oshima
297	1890 1 7 15 43	138.0	36.5		6.2			1		
298	1890 4 16 21 34	139.5	34.1		6.8					
299	1891 10 16 07 06	131.8	33.2		6.3					
300	1891 10 28 06 38	136.6	35.6		8.0			7,273	142,177	Neo-dani fault appeared
301	1891 12 24 05 35	138.9	35.4		6.5					
302	1892 6 3 07 10	139.9	35.7		6.2				1	
303	1892 12 9 10 42	136.7	37.1		6.4			1	2	
304	1893 6 4 02 27	148	$43^1/_2$		7	1				Tsunami hit southern Kurile
305	1893 9 7 02 25	130.5	31.4		5.3					Landslide
306	1894 1 4 22 09	130.5	31.4		6.2					
307	1894 3 22 19 23	146	$42^1/_2$		7.9	2		1	14	Some fore-shocks
308	1894 6 20 14 04	139.8	35.7		7.0			31	>32	
309	1894 8 8 23 19	131.0	32.8		6.3					Landslide
310	1894 10 7 20 30	139.8	35.6		6.7					
311	1894 10 22 17 35	139.9	38.9		7.0			726	>6,000	
312	1895 1 18 22 48	140.4	36.1		7.2			6	52	
313	1895 8 27 22 42	131.0	32.8		6.3					
314	1896 1 9 22 17	141	$36^1/_2$		6.6	0				
315	1896 4 2 01 41	137.3	37.5		5.7				17	
316	1896 6 15 19 32	144	$39^1/_2$		6.8	4		26,360	>11,000	Big tsunami hit n.-e. Japan
317	1896 8 31 17 06	140.7	39.5		7.2			209	6,024	
318	1897 1 17 00 49	139.9	36.2		5.6					
319	1897 1 17 05 36	138.3	36.7		5.3					Many after-shocks

Table 1 (Continued)

Event No.	Date and time	Epicenter λ(°E)	Epicenter φ(°N)	Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
320	1897 2 20 05 50	141.9	38.1		7.4	0			1	
321	1897 8 5 09 10	143.3	38.3		7.6	1				
322	1897 10 2 21 45	141.7	38.0		6.6					
323	1898 4 3 06 09	138.4	35.4		5.9					
324	1898 4 3 15 48	131.2	34.6		6.2				○	
325	1898 4 23 08 37	142.0	38.6		7.2	-1			1	
326	1898 5 26 03 00	138.9	37.0		6.1					
327	1898 8 10 21 57	130.2	33.6		6.0					Four earthquakes of same manitude occurred
328	1898 9 1 18 00	124.7	24.5		7.0					
329	1898 11 13 11 33	136.7	35.3		5.7					
330	1898 12 4 01 45	131.1	32.7		6.7					Central Kyushu
331	1899 3 7 09 55	136.2	34.2		7.0			>7	67	Landslide
332	1899 3 24 13 05	131.1	31.8		6.4					Southern Miyazaki
333	1899 3 31 23 01	136.6	35.6		$5^{1}/_{2}$					
334	1899 5 8 12 29	146.2	42.8		6.9					
335	1899 11 25 03 55	132.3	32.7		6.9	-1			2	Double earthq.
336	1900 3 12 10 34	141.9	38.3		6.4					
337	1900 3 22 00 55	136.2	35.8		5.8				2	
338	1900 5 12 02 23	141.1	38.7		7.0			>4	44	
339	1900 5 31 17 43	136.6	35.7		5.3					
340	1900 11 5 16 42	139.4	33.9		6.6				2	
341	1900 12 25 14 09	146	43		7.1					
342	1901 6 15 18 34	143	39		6.0	0				Off Rikuzen
343	1901 6 24 16 02	130	28		7.5	-1				
344	1901 8 9 18 23	142.5	40.5		7.2	0		○	8	
345	1901 9 30 19 19	141.9	40.2		6.9					
346	1902 1 30 23 01	141.3	40.5		7.0			1	3	
347	1902 3 25 14 35	140.5	35.9		5.5					
348	1902 5 25 20 29	139.0	35.6		5.4					
349	1902 5 28 18 01	144.8	42.8		6.6					
350	1902 12 11 05 06	130.0	31.0		5.3					
351	1903 3 21 19 36	132.2	33.8		6.2					
352	1903 7 6 13 55	136.5	35.0		5.7					
353	1903 8 10 13 40	137.6	36.2		$5^{1}/_{2}$					
354	1903 10 11 01 41	132.0	31.8		6.2					
355	1904 3 18 22 42	146.1	42.7		6.8					
356	1904 5 8 04 23	138.9	37.1		6.0					
357	1904 6 6 11 51	133.2	35.3		5.8					
358	1905 6 2 14 39	132.5	34.1		6.9			11	>64	
359	1905 6 7 14 39	139.3	34.8		5.8					Swarm
360	1905 7 23 17 26	138.4	37.1		5.2					
361	1905 12 23 11 37	141.8	38.5		6.1					
362	1906 2 23 18 49	139.8	34.8		6.3					

Table 1 (Continued)

Event No.	Date and time	Epicenter λ(°E)	Epicenter φ(°N)	Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
363	1906 2 24 09 14	139.8	35.5		6.4					
364	1906 4 21 04 38	137.2	35.9		5.9					
365	1906 5 5 08 09	135.3	33.9		6.2					
366	1906 10 12 10 04	140.5	40.0		5.5					
367	1907 3 10 22 03	130.7	32.9		5.4					
368	1907 7 6 00 46	145.5	43.7		6.7					
369	1907 12 2 22 53	142.3	40.1		6.7					
370	1907 12 23 10 13	145.0	43.8		6.9					
371	1908 4 16 12 27	130.6	31.7		4					
372	1908 12 28 17 08	138.7	35.6		5.8					
373	1909 3 13 08 19	141.5	34.5		6.7					
374	1909 3 13 23 29	141.5	34.5		7.5					
375	1909 7 3 05 54	139.8	35.6		6.1					
376	1909 8 14 15 31	136.3	35.4		6.8			37	>2,000	
377	1909 8 29 19 27	128	26		6					Okinawa
378	1909 9 17 04 39	142.0	42.0		6.8					
379	1909 11 10 15 13	131.1	32.3		7.6				3	
380	1910 7 24 15 49	140.9	42.5		5.3					Swarm due to activity of Volcano Usu
381	1910 9 8 11 50	141.6	44.2		5.3					
382	1910 9 26 19 26	141.5	36.8		5.9					
383	1911 2 18 05 14	131.5	31.9		5.6					
384	1911 2 18 23 45	136.3	35.4		5.5					
385	1911 6 15 23 26	130.0	28.0		8.0	0		7	1,918	
386	1911 8 22 07 48	131.0	32.9		5.5					
387	1911 9 6 09 54	143	46		7.1					
388	1912 4 18 16 37	142.0	38.6		5.8					
389	1912 6 8 13 41	142.0	40.5		6.6					
390	1912 7 16 07 46	138.5	36.4		5.7					Cliff fell down
391	1912 8 17 23 22	138.3	36.4		5.1					
392	1913 2 20 17 58	142.3	41.8		6.9					
393	1913 4 13 15 40	132.0	32.0		6.8					
394	1913 6 29 17 23	130.3	31.6		5.7				1	
395	1913 8 1 07 06	142.5	41.8		5.7					
396	1913 12 15 11 02	140.0	35.5		6.2					
397	1914 1 12 18 28	130.6	31.6		7.1			58	2,268	Due to eruption of Sakurajima
398	1914 3 15 04 59	140.4	39.5		7.1			94	931	
399	1914 3 28 02 50	140.4	39.2		6.2				1	
400	1914 5 23 12 38	133.2	35.3		5.7					
401	1914 11 15 22 29	138.1	37.1		5.7					
402	1915 3 18 03 45	143.6	42.2		7.0			2	○	
403	1915 6 20 01 01	139.0	35.5		5.9					
404	1915 7 14 21 13	130.8	31.9		5					
405	1915 11 1 16 24	142.9	38.3		7.5	0				
406	1915 11 16 10 38	140.3	35.4		6.0				○	

Table 1 (Continued)

Event No.	Date and time	Epicenter λ(°E)	Epicenter φ(°N)	Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
407	1916 2 22 18 12	138.5	36.5		6.2				7	
408	1916 3 6 18 12	131.6	33.5		6.1					
409	1916 8 6 07 52	133.4	34.0		5.7					
410	1916 9 15 16 01	141.2	34.4		7.0					
411	1916 11 26 15 08	135.0	34.6		6.1			1	3	
412	1916 12 29 06 41	130.5	32.3		6.1					Swarm
413	1917 1 31 00 40	139.0	35.2		$4^1/_2$					Swarm near Hakone
414	1917 5 18 04 07	138.1	35.0		6.3			2		
415	1918 5 26 07 30	141.6	44.2		5.4					
416	1918 6 26 22 46	139.1	35.4		6.3					
417	1918 9 8 02 16	152	$45^1/_2$		8.0		1	24		Tsunami hit southern Kurile
418	1918 11 11 02 59	137.9	36.5		5.9				22	
419	1919 11 1 08 36	132.9	34.8		5.8					
420	1920 12 27 18 21	139.0	35.2		5.5					
421	1921 4 19 02 58	132.1	32.6		5.5					
422	1921 9 6 05 02	153.0	47.8							
423	1921 12 8 21 31	140.2	36.0		7.0					
424	1922 1 23 07 05	141.5	37.5		6.4					
425	1922 4 26 10 11	139.8	35.2		6.8			2	11	
426	1922 5 9 12 28	140.0	36.0		6.1					
427	1922 12 8 01 50	130.1	32.7		6.9			26	654	
428	1923 1 14 14 51	139.9	36.1		6.1					
429	1923 7 13 20 13	131.2	30.6		7.0					
430	1923 9 1 11 58	139.5	35.1		7.9	2		142,807	576,262	Great Kanto earthquake
431	1923 9 1 16 38	138.9	35.5		6.6					Aftershocks of No. 430 (Nos. 431–435)
432	1923 9 2 11 46	140.2	34.9		7.3	-1				
433	1923 9 10 02 11	139.2	34.8		5.9					
434	1923 9 26 17 24	139.4	34.8		6.7					
435	1924 1 15 05 50	139.2	35.5		7.3			19	1,302	
436	1924 3 15 19 32	142.1	48.8						4	
437	1924 8 13 03 18	135.2	33.9		5.9					
438	1925 5 23 11 09	134.8	35.6		6.8			465	4,061	
439	1925 7 4 04 20	133.3	35.5		5.8					
440	1925 7 7 01 46	136.5	35.4		5.8					
441	1925 8 10 09 37	130.9	33.3		4.4					Central Kyushu, Swarm
442	1926 6 29 23 26	127.2	25.0							
443	1926 8 3 18 26	139.8	35.4	35	6.2					
444	1926 9 5 00 37	143.7	42.0	40	6.8					
445	1927 3 7 18 27	135.1	35.6	10	7.5	-1		2,925	21,690	Conjugate faults appeared
446	1927 8 6 06 13	142.0	38.0	20	6.9	-1				

Table 1 (Continued)

Event No.	Date and time	Epicenter λ(°E)	Epicenter φ(°N)	Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
447	1927 10 27 10 53	138.8	37.5	0~10	5.3					
448	1927 12 2 15 55	135.2	34.1	10	5.3					Many aftershocks
449	1928 5 21 01 29	140.3	35.6	60	5.8					
450	1928 11 5 13 41	130.9	33.2	0~10	4.9					
451	1929 1 2 01 40	130.9	33.1	0	5.4					
452	1929 5 22 01 35	132.2	31.7	30	6.8					
453	1929 7 27 07 48	139.1	35.5	20	6.1					
454	1929 8 8 22 33	130.3	33.5	0	4.7					
455	1929 11 20 14 54	135.2	34.2	10	5.6					
456	1930 2 5 22 28	130.25	33.5	20	5.1					
457	1930 2 11 09 11	135.1	34.2	10	5.2					
458	1930 3 22 17 50	139.1	34.8	20	5.8					Swarm
459	1930 6 1 02 58	140.7	36.4	30	6.6					
460	1930 10 17 06 36	$136^{1}/_{3}$	$36^{1}/_{3}$	20	6.4					Cliff fell down
461	1930 11 26 04 03	139.0	35.1	0~5	7.0			259	2,203	Tanna fault
462	1930 12 20 23 02	132.8	34.9	20	6.0					
463	1931 2 17 03 48	142.6	42.3	40	6.8					
464	1931 3 9 12 49	142.5	41.2	0	7.6	-1				
465	1931 3 30 02 52	143.8	42.8	80						
466	1931 9 21 11 20	139.2	36.1	10~20	7.0			16	207	Rumbling heard at distant places
467	1931 11 2 19 03	132.1	32.2	20	6.6	-1		1	5	
468	1931 11 4 01 20	141.7	39.5	0~10	6.1					
469	1931 12 21 14 47	130.4	32.6	0	5.4					
470	1932 11 26 13 24	142.4	42.4	40	6.8					
471	1933 3 3 02 31	144.7	39.1	0~20	8.3	3		3,064	6,067	Big tsunami hit n.-e. Japan
472	1933 4 8 20 54									Kumamoto
473	1933 8 20 06 37									Off Sendai
474	1933 9 21 12 14	137.0	37.1	15	6.0			3	12	
475	1933 10 4 03 39	138.9	37.3	30	6.1					
476	1934 3 21 12 40	138.9	34.8	0~10	5.5					
477	1934 8 18 11 38	137.0	35.7	0~10	6.2					
478	1935 7 3									Miyazaki
479	1935 7 11 17 25	138.4	35.0	10	6.3			9	814	
480	1936 2 21 10 08	135.7	34.5	20	6.4			9	18	
481	1936 11 3 05 46	142.2	38.2	50~60	7.7	-1			3	
482	1936 11									Swarm. Aizu-Wakamatsu
483	1936 12 27 09 14	139.2	34.5	0~20	6.3			3	39	
484	1937 1 27 16 04	130.8	32.8	0~10	5.0					
485	1937 7 27 04 56	142.0	38.2	50	7.2					
486	1938 1 2 16 54	133.4	35.0	10	5.3					
487	1938 1 12 00 12	135.2	33.7	20	6.7					
488	1938 5 23 16 18	141.4	36.7	10	7.1	-1			1	

Table 1 (Continued)

Event No.	Date and time	Epicenter λ(°E)	Epicenter φ(°N)	Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
489	1938 5 29 01 42	144.3	43.6	20	6.0	-1		1	5	Lake flooded
490	1938 6 10 18 53	125.2	25.3	shallow	6.7	1				Wave height ≒1.5m
491	1938 9 22 03 52	141.0	36.4	10	6.6					
492	1938 11 5 17 43	141.7	37.1	20	7.7	0		1	20	4 aftershocks have magnitude more than 7.0
493	1939 3 20 12 22	131.7	32.3	10	6.6	-1		1		
494	1939 5 1 14 58	139.8	40.0	0	7.0	-1		27	585	
495	1940 8 2 00 08	139.5	44.1	0~20	7.0	2		10	20	Tsunami hit western coast of Hokkaido
496	1941 3 7 12 00	138.4	36.7	5	5.0					
497	1941 4 6 01 50	131.65	34.6	10	6.2					
498	1941 7 15 23 45	138.3	36.7	5~20	6.2			5	77	
499	1941 11 19 01 46	132.1	32.6	0~20	7.4	1		2	27	Tsunami hit eastern coast of Kyushu
500	1942 2 21 16 08	142.0	37.65	60	6.6					
501	1943 3 4 19 13	134.2	35.6	20	6.1				68	Triple shock
502	1943 8 12 13 50	139.8	37.3	15	6.1					
503	1943 9 10 17 37	134.2	35.5	10	7.4			1,083	7,736	Two faults appeared
504	1943 10 13 14 42	138.2	36.8	0	6.1			1	34	
505	1944 12 7 01 27	140.2	38.3	0~30	5.8				1	
506	1944 12 7 13 35	136.2	33.7	0~30	8.0	3		>871	>13,586	Tsunami (max height 6~8m) hit Kii and Tokai area
507	1945 1 13 03 38	137.0	34.7	0	7.1	-1		1,961	5,539	Fukozu fault
508	1945 2 10 13 58	142.1	40.9	30	7.3	-1		2	2	
509	1946 12 21 04 19	135.6	33.0	30	8.1	3		1,330	15,710	Tsunami hit s.-w. Japan
510	1947 5 9 23 05	131.1	33.3	20	5.5					
511	1947 9 27 01 04							5		Okinawa
512	1947 11 4 09 09	141.0	43.8	v.s.	7.0	1				
513	1948 5 9 11 09	131.8	31.5	0	6.7					
514	1948 6 15 20 44	135.5	33.8	v.s.	7.0			2	60	
515	1948 6 28 16 13	136.2	36.1	20	7.3			3,769	40,035	
516	1949 1 20 22 25	134.6	35.6	20	6.5					
517	1949 7 12 01 10	132.5	34.0	40	6.2			2		
518	1949 12 26 08 25	139.7	36.7	v.s.	6.7			10	908	Double shock. Many landslides
519	1950 4 26 16 05	135.8	33.8	40	6.7					Landslide
520	1950 8 22 11 04	132.7	35.2	30	5.3					
521	1950 9 10 12 21	140.5	35.3	30~40	6.5					
522	1951 1 9 03 32	140.1	35.4	40	6.2					
523	1951 8 2 18 57	138.5	37.1	0~10	5.2					
524	1951 10 18 17 26	142.1	41.4	40	6.5					

Table 1 (Continued)

Event No.	Date and time	Epicenter λ(°E)	Epicenter φ(°N)	Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
525	1952 3 4 10 23	143.85	42.15	45	8.1	2		33	>906	Tsunami hit n.-e. Japan
526	1952 3 7 16 32	136.20	36.45	20	6.8			7	10	
527	1952 3 10 02 04	143.5	41.7	0~20	7.0	-1			○	
528	1952 7 18 01 10	135.80	34.45	70	7.0			9	>20	
529	1952 11 5 02 01	162	52	s.	$8^1/_4$	1				Tsunami hit Pacific coast of Japan
530	1953 11 26 02 48	141.8	34.3	40~60	7.5	1				
531	1955 6 23 22 41	133.4	35.2	20	5.1					
532	1955 7 27 10 20	134.3	33.75	0~10	6.0			1		
533	1955 10 19 10 45	140.2	40.3	0~10	5.7				1	100 after-shocks in 24 hrs after the event
534	1956 2 14 09 52	139.9	35.7	50	6.0					
535	1956 3 6 08 29	144.1	44.3	0~20	5.8	-1				
536	1956 9 30 06 20	140.55	37.95	20	6.1			1	○	
537	1956 9 30 08 20	140.2	35.5	70	6.5					
538	1957 3 1 01 56	140.3	40.2	0~10	4.1					
539	1957 11 11 04 20	139.35	34.30	0	6.3				2	Swarm
540	1958 3 11 09 26	124.5	24.75	80	(7)			1		(7)=MPAS
541	1958 11 7 07 58	148.5	44.3	80	8~8.25	1				
542	1959 1 31 05 38	144.40	43.35	20	6.2				1	Double shocks
543	1959 2 28 05 56	128.5	27.5	s.	6.0					
544	1959 11 8 22 54	140.6	43.8	0~10	6.2					
545	1960 3 21 02 07	143.5	39.8	20	7.5	0				
546	1960 5 23 04 11	73.5°W	38.0°S		8.5	2~3		139	2,830	Tsunami due to Chilean earthq.
547	1961 2 2 03 39	138°50′E	37°27′N	20	5.2			5	259	
548	1961 2 27 03 10	131 51	31 36	40	7.0	0		2	>3	
549	1961 3 14 18 27	130 43	31 58	20	4.6					
550	1961 8 12 00 51	145 34	42 51	80	7.0	-1				
551	1961 8 19 14 33	136 46	36 01	0	7.0			8	>12	
552	1962 4 23 14 58	143 55	42 14	60	7.0					
553	1962 4 30 11 26	141 08	38 44	0	6.5			3	>340	
554	1962 8 26 15 49	139 27	34 07	40	5.9				5	Swarm due to volcanic activity
555	1963 1 28 13 05	145 00	43 35	40	5.3					
556	1963 3 27 06 34	135 46	35 47	0	6.9				5	
557	1963 10 13 14 18	149 58	43 45	20	8.1	2				Small tsunami hit eastern Hokkaido
558	1963 11 13 14 01	139 13	34 17	0	4.7					
559	1964 1 20 02 10	145 13	44 03	0	4.6					
560	1964 3 28 12 36	147.8°W	61.0°N		8.5	0				Tsunami hit Pacific coast of Japan

Table 1 (Continued)

Event No.	Date and time	Epicenter λ(°E)	φ(°N)	Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
561	1964 5 7 16 58	139°00′E	40°20′N	0	6.9	-1			3	
562	1964 6 16 13 01	139 11	38 21	40	7.5	2		26	>2,250	Quick sand phenomena appeared
563	1964 6 23 10 26	146 28	42 59	80	6.9					
564	1964 12 9 02 49	139 18	34 35	0	5.8					Swarm
565	1964 12 11 00 11	138 56	40 25	40	6.3	-1				
566	1965 2 4 14 01	178.6	51.3	40	7.5	0				
567	1965 4 20 08 42	138 18	34 53	20	6.1			2		
568	1965 8~								10	Matsushiro earthq. Swarm. Continued for 5 yrs.
569	1965 8 3 17 30	139 18	34 16	0	5.0					
570	1965 8 31 16 49	144 26	43 29	0	5.1					Double shock
571	1965 10 26 07 34	145 31	43 44	160	6.8					
572	1965 11 6 07 02	139 02	34 08	0	5.2					
573	1966 3 13 01 31	122.6	24.2		7~7.5			6		
574	1966 11 12 21 01	130 16	33 04	20	5.5					
575	1967 4 6 15 17	139 09	34 13	10	5.3				7	Swarm
576	1967 11 4 23 30	144 16	43 29	20	6.5					
577	1968 2 21 10 45	130 43	32 01	0	6.1			3	>368	
578	1968 2 25								2	Swarm near Niishima
579	1968 4 1 09 42	132 32	32 17	30	7.5	1			1	
580	1968 5 16 09 49	143 35	40 44	0	7.9	2		52	>673	
581	1968 7 1 19 45	139 26	35 59	50	6.1					
582	1968 7 17 01 53									North-w. Hokkaido
583	1968 8 6 01 17	132 23	33 18	40	6.6				1	
584	1968 8 18 16 12	135 23	35 13	0	5.6					
585	1968 9 21 07 25	138 16	36 49	10	5.3					
586	1968 9 21 22 06	142 48	41 59	80	6.8					
587	1968 10 8 05 49	142 43	41 49	60	6.2					
588	1968 11 12 09 44	128 25	27 28	20	5.6					
589	1969 4 21 16 19	132 07	32 09	10	6.5					
590	1969 8 12 06 28	147 37	42 42	30	7.8	0				
591	1969 9 9 14 15	137 04	35 47	0	6.6			1		
592	1970 1 1 04 02	129 13	28 24	50	6.1					
593	1970 1 21 02 33	143 08	42 23	50	6.7				2	
594	1970 3 13 22 27	132 49	34 56	10	4.6					
595	1970 4 9 01 44	138 06	36 26	0	5.0					
596	1970 7 26 07 41	132 02	32 04	10	6.7	-1				
597	1970 9 29 19 11	133 18	34 26	10	4.9					
598	1970 10 16 14 26	140 45	39 12	0	6.2				1	
599	1971 2 26 04 27	138 21	37 08	0	5.5					
600	1971 8 2 16 25	143 42	41 14	60	7.0	-1				
601	1971 11 10 17 37	138 20	36 37	0	4.5					

Table 1 (Continued)

Event No.	Date and time					Epicenter λ(°E)		φ(°N)		Depth (km)	M	m	[ ]	No. of dead	No. of buildings totally destroyed	Remarks
602	1972	1	14	16	14	139	19	34	48	0	3.8					
603	1972	2	29	18	23	141	16	33	11	70	7.0	-1				
604	1972	7	7													Okinawa
605	1972	8	20	19	09	139	57	38	36		5.3					
606	1972	8	31	17	07	136	46	35	53	10	6.0					
607	1972	12	4	19	16	141	05	33	12	50	7.2	-1				
608	1973	6	17	12	55	145	57	42	58	40	7.4	0			2	
609	1973	11	25	13	25	135	25	33	51	60	5.9					
610	1974	5	9	08	33	138	48	34	34	10	6.9	-1		38	139	
611	1974	6	23	10	40	141	11	38	41	0	4.7					
612	1974	8	3	03	16	139	55	36	01	50	5.8			2		
613	1974	9	4	18	20	141	56	40	11	40	5.6					
614	1974	11	9	06	23	141	47	42	29	130	6.5					
615	1975	1	23	19	15	131	08	33	00	0	6.1				16	
616	1975	4	21	02	35	131	20	33	08	0	6.4				95	
617	1975	8	15	03	09	141	08	37	04	50	5.5					

v.s. means very shallow, s. means shallow.

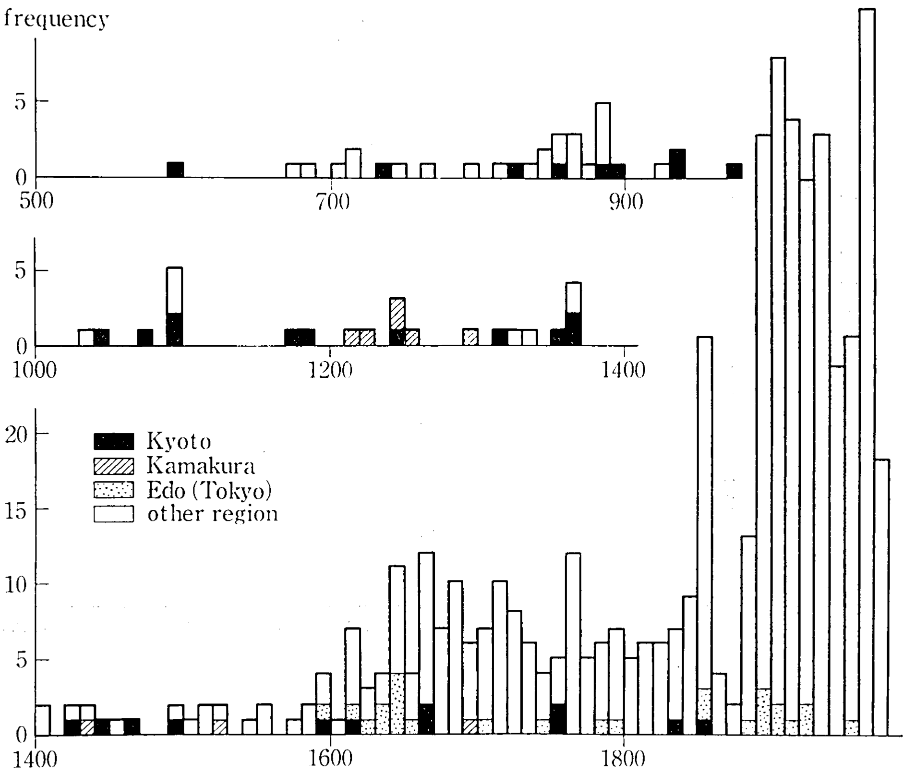

Fig. 7. Number of disastrous earthquakes in every ten years.
Solid part: Kyoto area. Hatched part: Kamakura area. Dotted part: Tokyo area

special earthquakes, values revised by the present author were adopted.

Magnitude of tsunami (m) is defined as follows;

−1 Wave height is less than 50 cm. No damage.

0 Wave height is about 1 m. Slight damage.

1 Wave height is about 2 m. Damage to houses on the shore. Boats may be washed away.

2 Wave height is 4∼6 m. Loss of human life and houses.

3 Wave height is about 10 m. Heavy damage along coast for more than 400 km.

4 Maximum wave height is more than 30 m. Heavy damage along coast for more than 500 km.

Values of m adopted in Table 1 are mainly those by WATANABE (1968). The grade of damage defined by Imamura (see MUSHA, 1950-1953) is as follows:

0 In epicentral region, usual wooden houses suffer damage, but do not fall down. Stone hedges and castle walls fall down occasionally. Acceleration in the epicentral region is about 10% of gravity

acceleration.

I Mean radius of heavily hit area (where rate of destroyed wooden houses to total wooden houses is more than $1\sim2\%$) is less than 10 km.

II Mean radius of heavily hit area is less than 20 km. In the epicentral region, acceleration reached to more than 30% of gravity acceleration. Remarkable fault appears.

III Mean radius of heavily hit area is less than 40 km. Remarkable fault appears.

IV Mean radius of heavily hit area reaches to 50 km. Remarkable fault system appears. Vertical change of the ground appears in a wide area.

Grade value of damage given by Imamura for earthquakes before 1872 are shown in Table 1.

In historical time, field survey of damage was incomplete. However, since there are no alternative descriptions, damages as described in old documents are adopted. They are not accurate in the modern sense, but they convey to us a general impression of the largeness of the earthquake. Accuracy of occurrence time for historical earthquakes is 2 hours. That of epicenter location is about $10\sim20$ km for inland

Table 2. Number of disastrous earthquakes by magnitude.

Year	Magnitude						Total
	$M<5$	$5\leqq M<6$	$6\leqq M<7$	$7\leqq M<8$	$8\leqq M$	Unknown	
500-599				1			1
600-699			1		1		2
700-799			2	4		1	7
800-899			6	10	2		18
900-999			3	1			4
1000-1099			6		2		8
1100-1199			1	1			2
1200-1299			4	3			7
1300-1399			4	2	1	1	8
1400-1499			4	3	1	3	11
1500-1599			9	3		3	15
1600-1649		1	12	8	1	4	26
1650-1699		6	16	8	1	8	39
1700-1749		3	21	3	2	6	35
1750-1799		3	13	11		8	35
1800-1849		5	17	6	1	4	33
1850-1867		5	10	2	2	10	29
1868-1899		15	21	13		6	55
1900-1924		34	42	17		9	102
1925-1949	2	17	34	18	3	7	81
1950-1975	9	26	37	19	6	2	99
Total	11	115	263	133	23	72	617

Table 3. Number of disastrous earthquakes by tsunami magnitude.

Year	Tsunami magnitude							Total
	−1	0	1	2	3	4	Unknown	
500- 599								
600- 699					1			1
700- 799				1			1	2
800- 899			1	2	1	1		5
900- 999			1					1
1000-1099				1				1
1100-1199								
1200-1299			2					2
1300-1399				1	1			2
1400-1499			3		1			4
1500-1599			2	1				3
1600-1649			2	1	1	1		5
1650-1699			1	2	1		2	6
1700-1749			3		2	1	1	7
1750-1799			9	1	1	1		12
1800-1849			2	3				5
1850-1867				2	1	1		4
1868-1899	2	4	2	1		1		10
1900-1924	2	4	1	1				8
1925-1949	11	1	3	1	3			19
1950-1975	9	7	4	4		1	1	26
Total	24	16	36	22	13	7	5	123

Table 4. Number of disastrous earthquakes by grade of damage.

Year	Grade of damage					Total
	0	I	II	III	IV	
500- 599		1				1
600- 699		1			1	2
700- 799	1	1	2	1	1	6
800- 899	1	3	6	2	3	15
900- 999		2	1			3
1000-1099	4	1		1	1	7
1100-1199				1		1
1200-1299	4		3			7
1300-1399	1	2	2		1	6
1400-1499	1	4	3		1	9
1500-1599	1	3	3		1	8
1600-1699	5	11	7	6	2	31
1700-1799	3	10	11	7	3	34
1800-1872	10	12	10	4	3	39
Total	31	51	48	22	17	169

Table 5. Number of disastrous earthquakes by the number of dead persons.

Year	Number of dead persons							Total
	0~9	10~99	100~999	1000~9999	10000~	Unknown	Many	
500- 599						1		1
600- 699						2		2
700- 799						7		7
800- 899	2	1		2		8	5	18
900- 999	2	1				1		4
1000-1099	5		1			1	1	8
1100-1199	1						1	2
1200-1299	4			1		2		7
1300-1399	3	1		1		2	1	8
1400-1499	2				1	6	2	11
1500-1599	5	1	2	1		5	1	15
1600-1699	46	2	3	4		4	6	65
1700-1799	43	6	2	7	1	8	3	70
1800-1867	35	8	5	6		6	2	62
1868-1899	49	2	3		1			55
1900-1949	161	12	3	6	1			183
1950-1975	94	4	1					99
Total	452	38	20	28	4	53	22	617

earthquakes and 50~100 km for earthquakes off the coast. Accuracy of magnitude depends on the abundance of old documents and is 1/4~1.0.

The contents of Table 1 on historical earthquakes are not as accurate as those on modern ones, but they give us general ideas about seismic activity in the long range. Tables 2~5 are helpful to confirm the general tendency of seismicity in historical time in Japan.

4. Recent Works on the Collection of Old Documents.

Since the publication of "Historical data on Japanese earthquakes", no extensive work of collecting old documents has been done by any Japanese until 1971, when the present author began the collection of old documents. In the beginning, he collected documents by himself. Since then, keen interest in historical earthquakes has increased among seismologists, especially in relation to the long-range prediction of earthquakes and mitigation of earthquake disasters. In 1976, the possibility of a Tokai earthquakes was pointed out by Ishibashi (ISHIBASHI, 1977). From the end of 1976, by the strong desire of the Ministry of Education, the Historiographical Institute of Tokyo University agreed to cooperate with the Earthquake Research Institute in the work of collecting and reading old documents. This is a great advantage to the Earthquake Research Institute. Historians keep a lot of information about old documents and can show seismologists where to go and what to see. Through this cooperation, the collection of old documents has been accelerated. The cooperation also gives us other benifits such as reading documents in the bookrooms (not in the reading rooms) of libraries, so that the efficiency of finding old records relating to earthquakes has been much improved.

On an average, about 5,000 sheet of photographs or xerox copies (corresponding to 10000 pages ca.) of old documents are collected annually. For Japanese records, reading documents is the most time-consuming job and is a drawback for putting old documents in order so that they may easily be made available to any seismologist. This work costs much and it is now being processed slowly but steadily.

Hatori, a lecturer of the Earthquake Research Institute, who has interests in the study of tsunami, has been working on the collection of historical data of tsunami, that is, those in old documents and carved on stone monuments. He has made field surveys of tsunami by referring to descriptions in old documents or on stone monuments and has ascertained the height of tsunamis at some spots on the shore, making comparison with precise maps made by the Geographical Survey Institute. He has made a synoptic study of famous historical tsunamis and estimated source region of a tsunami by using the arrival time of the tsunami wave.

Daicho, a staff member of the Kansai Electric Company, has concentrated his efforts on the study of two big earthquakes in Kansai district. The one is the earthquake of May 12, 701 (No. 4 of Table 1) and the other is the earthquake of June 16, 1662 (No. 115 of Table 1). He employed historical, geological, and seismological methodologies and has made contributions to research by clearing up ambiguities inevitably included in old documents and proposing revised epicenter location and magnitude.

Tsuji, a staff member of the National Research Center for Disaster Prevention, has a deep interest in tsunami phenomena. He is energetically collecting historical data on earthquakes and tsunamis. He published "Data book on historical earthquakes" (TSUJI, 1979) which includes data mainly relating to Shizuoka, Nagano and Yamanashi prefectures.

Shimazaki and Ishibashi are interested in relating historical data to the problem of the plate tectonics theory. Ito too has interest in the collection of and study based on historical data. Miss Uyeda helps the author in reading, collecting and arranging historical data.

5. Recent Study based on Historical Data.

The first purpose of the collection of old documents is in preparing basic and reliable data for the study of historical earthquakes. On the other hand, we, geophysicists, would like to use historical data for modern geophysical studies such as plate tectonics, fault movement, earthquake mechanism and so on.

In this section some works done by Japanese seismologists employing newly found old documents are introduced.

1) Earthquakes of April 9, 1858 (No. 270 of Table 1)

This earthquake had been thought to be due to the movement of the Atotsugawa fault. Using old documents regarding to damage of houses, Figures 8 and 9 were prepared. Figure 8 shows by symbols the damage rate to each village, that is,

$$\frac{\text{(the number of houses totally destroyed)} + \frac{1}{2}\text{(the number of half destroyed houses)}}{\text{(the total number of houses)}} \times 100\%$$

The distribution of this rate clearly shows that villages with a rate of more than fifty percent lie along the fault line. On the other hand, it is clear from the character of documents employed in the study that

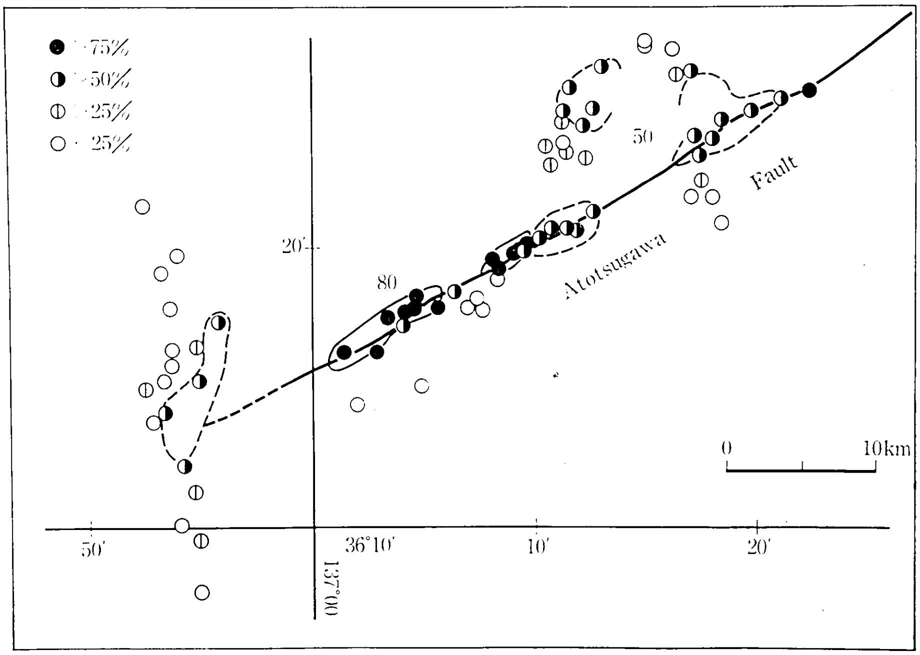

Fig. 8. Distribution of the rate of damage for villages near the Atotsugawa fault.

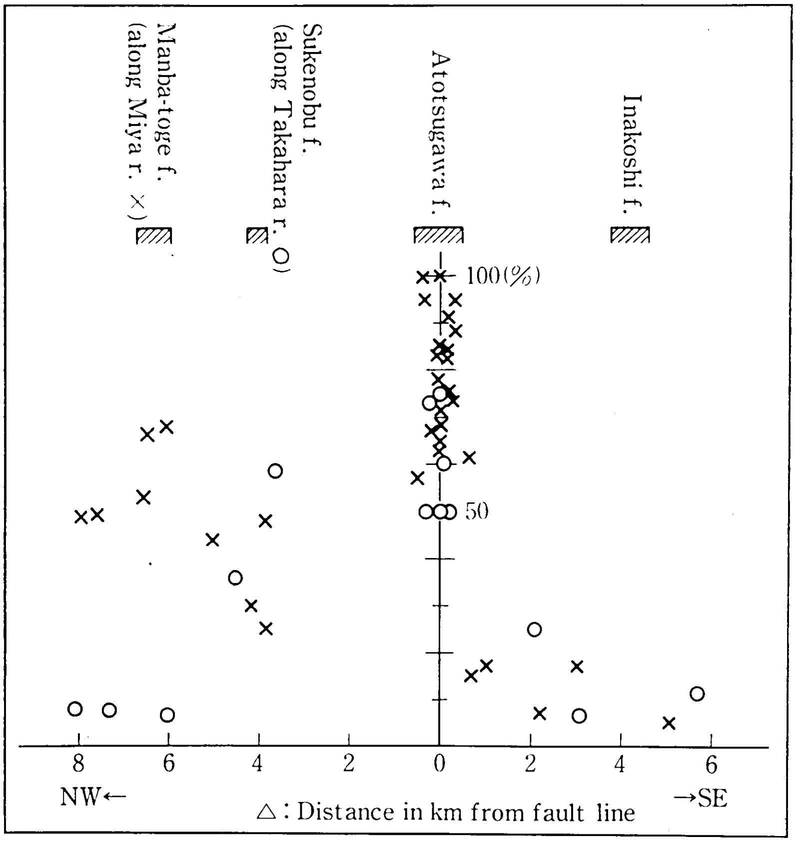

Fig. 9. Relation between the rate of damage and distance from the fault line. Different symbols are used for villages along different rivers.

villages north of the figure have some damage which will be made clear from a detailed study of the other documents.

Figure 9 shows the relation between the rate of damage and the distance from the fault line on both sides of the fault. Villages with different symbols lie along different rivers. The figure suggests that the cause of the earthquake is the movement of the fault and that the north side of the fault moved up. This suggestion coincides with the results obtained from long-range movement of the fault revealed by geological method, that is, the right lateral movement with north side upwards. It is reasonably believed from these figures that a relation between the earthquake and the movement of the fault has clearly been settled (USAMI *et. al.*, 1979).

2) Change of the seismicity in north-eastern Japan

Seismicity in the Pacific side of north-eastern Honshu in the Yedo period (1603-1867) was studied employing new data (USAMI *et al.*, 1978). The result is shown in Fig. 10 in which the solid part shows earth-

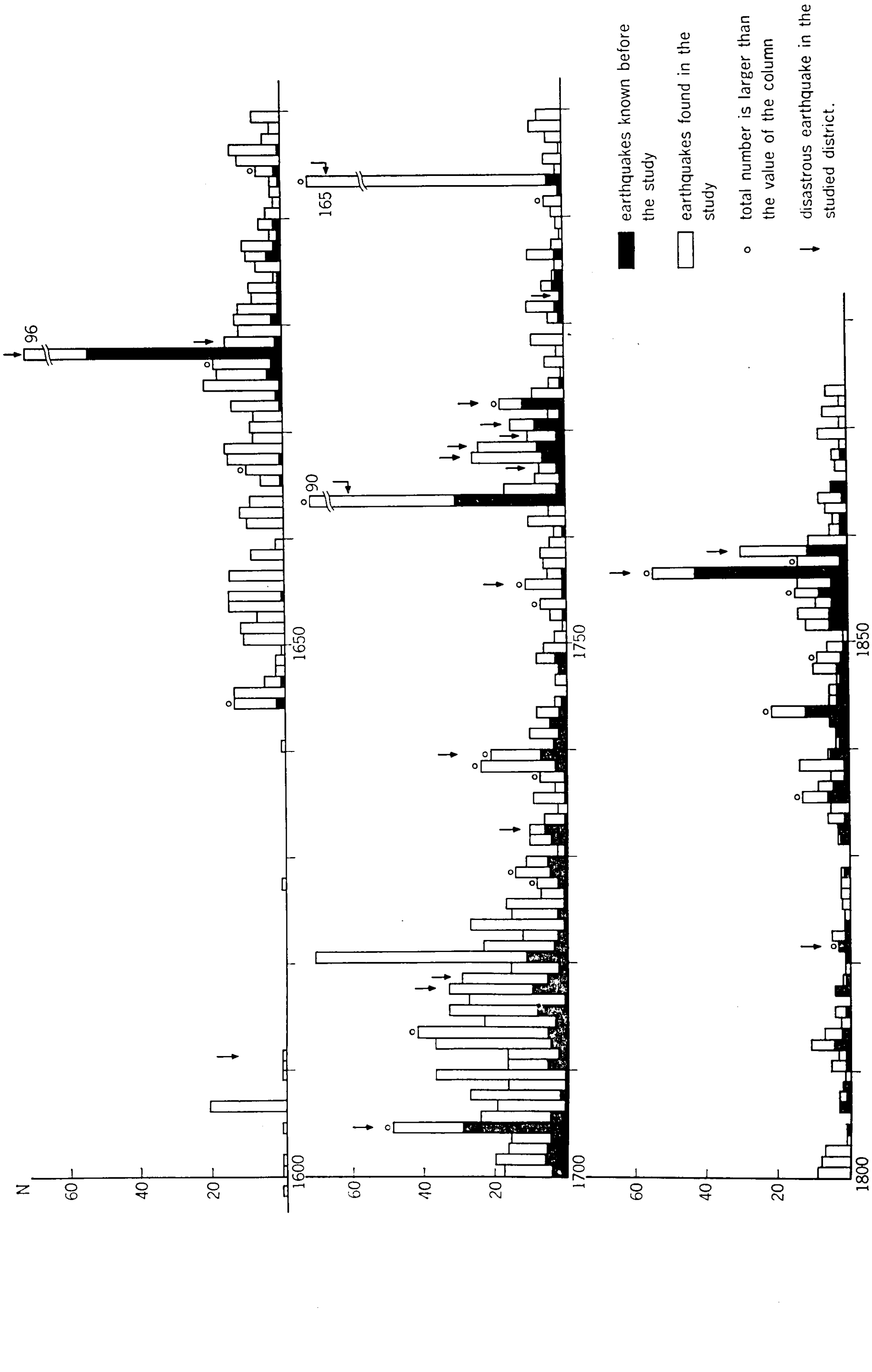

Fig. 10. Annual number of earthquakes in the north-eastern Tohoku district during 1598-1873.

quakes adopted in "Historical data on Japanese earthquakes" (MUSHA 1942~1943, 1949) and the open part shows those found in the study. The number of earthquakes for the solid part is 538 and those in the open part is 1939. The number of earthquakes has become four times as before. However, it is still too few to say anything about the change of seismicity in historical time. However, from the total number of earthquakes, we can see relatively active and inactive periods. Periods of comparatively high seismicity seem to be in 1650~1730, 1763~1773 and 1850~1860.

Detailed study of several destructive earthquakes reveals, as HATORI (1975) says, that the following four earthquakes have similar characteristics and took place in the same region with intervals of about 100 years.

Year and Date	Epicenter		M
Dec. 2, 1611	39.0°N	144.5°E	8-8 1/4
Jan. 29, 1763	40.5	143.5	7 3/4
Aug. 8, 1856	40.5	143.5	8
May 16, 1968	40.7	143.6	7.9

This regularity seems to be surprising as that revealed by natural intermittent phenomena. Another regularity in the Nankai district is famous among Japanese seismologists as shown in Table 6. The relation between destructive earthquakes in Nankai and Tokai area is another example of such surprising phenomena as shown in Table 7. It may be said that, within two years after the occurrence of a large earthquake in the Tokai district, with a high probability a similar event may take place in the Nankai district.

3) Hatori published several studies of historical tsunami by the comparison of descriptions in old documents and field studies. As an

Table 6. List of huge earthquakes off the Nankai district.

Year	Month	Day	Epicenter φ(°N)	Epicenter λ(°E)	M	Subsided area near Kochi City	Upheaval of Cape Muroto	Hot spring at Yunomine
684	Nov.	29	32.5	134.0	8.4	12 km^2		
887	Aug.	26	33.0	135.3	8.6			
1099	Feb.	22	33.0	135.5	8.0	>10 km^2		
1361	Aug.	3	33.0	135.0	8.4			Well up stopped
1605	Feb.	3	33.0	134.9	7.9			
1707	Oct.	28	33.2	135.9	8.4	20 km^2, 2m>	1~2 m	Well up stopped
1854	Dec.	24	33.0	135.0	8.4	1~1.5 m	1.2 m	〃
1946	Dec.	21	33.0	135.6	8.1	15 km^2	1.3 m	Well up decreased markedly

Table 7. Temporal relation among huge earthquakes off Kanto, Tokai and Nankai districts.

Off Kanto district		Off Tokai district		Off Nankai district
				684 Nov. 29
818 —— ——				
				887 Aug. 26
		1096 Dec. 17	(2 years ca.) →	1099 Feb. 22
				1361 Aug. 3
		1498 Sept. 20		
1605 Feb. 3	——(same day)——	——	——→	1605 Feb. 3
1703 Dec. 31	(4 years ca.) →	1707 Oct. 28	(same day) →	1707 Oct. 28
		1854 Dec. 23	(32 hrs.) →	1854 Dec. 24
1923 Sept. 1	(21 years ca.) →	1944 Dec. 7	(2 years ca.) →	1946 Dec. 21

example, the study of the earthquake of Dec. 23, 1854 in Shizuoka Prefecture is shown in Fig. 11 (HATORI, 1976). Numerals mean estimated tsunami height in meters above the mean sea level. He estimated the tsunami source area using the arrival time of the tsunami wave after the occurrence of the earthquake as shown in Fig. 12 (HATORI, 1977). Tsuji also has interests in historical earthquakes and is doing much work on the collection of old documents, but no paper is yet in written form.

Ishibashi found in old documents basic data pertaining to a conclusion that at the time of the Tokai earthquakes of Dec. 23, 1854 the Suruga bay was a part of the tsunami source region. In other

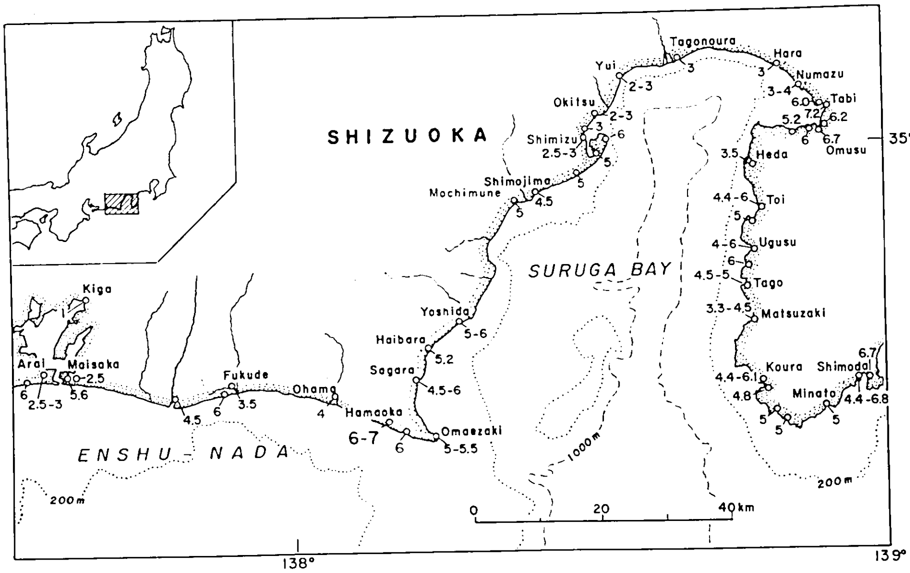

Fig. 11. Distribution of the inundation heights (above M. S. L., unit: m) along the Shizuoka coast for the earthquake of Dec. 23, 1854.

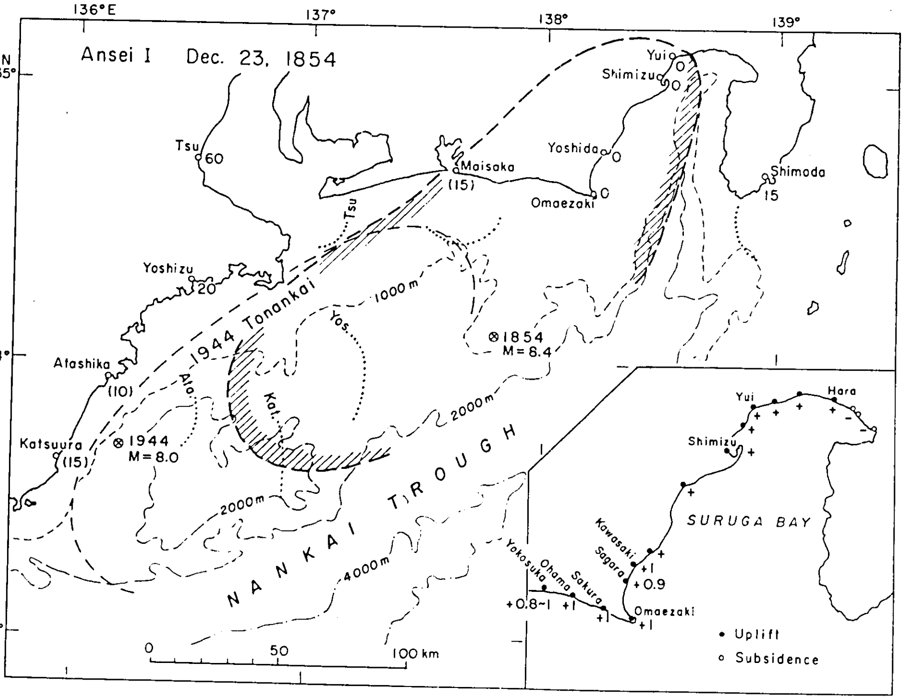

Fig. 12. Distribution of tsunami travel times (min.) inferred from old documents and the estimated source area for the earthquake of Dec. 23, 1854. The right lower figure shows vertical crustal deformation in m.

words, the epicentral region of that event, hitherto considered as lying off the Pacific coast, should include Suruga bay. Based on this and other facts obtained by field observations and discussions in plate tectonics theory, he proposed a possibility of having another disastrous earthquake in that area in the near future.

SHIMAZAKI (1976) has made a intra-plate seismicity map for southwest Japan, based on fairly complete historical data for the past four hundred years. It revealed an inverse correlation between the seismic activity along the island arc and the slip-rate along the Median Tectonic Line during the late Quaternary. In the eastern part, the tectonic line is geologically inactive but regional historic seismicity has been high. Conversely, the historic seismicity has been low in the western part, especially low in an area along the most geologically active segment of the Median Tectonic Line. According to his study, since no creep movement has been found there, energy greater than that of the Nobi earthquake of 1891 ($M=8.0$) seems to be stored along the Median Line in the western part.

Wide interest in historical earthquakes is spreading among Japanese seismologists, and several fault models of some destructive historical earthquakes have been proposed by young seismologists.

4) Study based on old documents is not the sole method of investigating historical earthquakes. Geological methods are important. However, even when geological study may find some reliable data on historical earthquakes, it can not fix date of a special earthquake. Therefore the cooperation of geological and historical studies is effective for the study of historical events. MATSUDA (1975) has concentrated his efforts in the study of active faults, making maps of active faults in Japan, classifying them into three types and arriving at the conclusion that, in general, the interval of consecutive large earthquakes in one region is about 100~200 years for those off the Pacific coast of Japan and about 1000 years for inland events.

For the earthquake of June 16, 1662, Matsuda and Okada (USAMI *et al.*, 1977) made field investigations and confirmed the fault movement found in old documents.

Group of seismologists of Kyoto and Aichi Prefectural Universities (ANDO *et al.* 1979: OKADA *et al.*, 1979) tested a method of digging a trench across the Yamasaki fault line and found evidence that the fault has displaced at least twice. One displacement seems to correspond to the earthquake of Aug. 3, 868 and we are now waiting for the results of age dating of materials found in the trench. The other displacement seems to correspond to an older event which can not be identified from the the study of old documents. This test may confirm the relation between the Yamasaki fault and the 868 earthquake which may be important for the prediction of movement of the fault, since we have had no earthquakes associated with the fault after 868.

This article was written, by the recommendation of the Editorial Committee of the Bulletin, in order to give general ideas about the study of historical earthquakes in Japan. Japan is abundant in historical data. The project of collecting them started about ninety years ago, namely, in 1893. Studies based on these data have been and are active in Japan. However, unfortunately, most of studies on historical earthquakes and lists of historical earthquakes in Japan were published in Japanese, so they are inaccessible to western seismologists. Recently world-wide interest in historical earthquakes seems to be increasing in relation to the problem of earthquake prediction. It would be meaningful to give an introductory article on the study of historical earthquakes in Japan, because Japan is the most abundant in historical data on earthquakes and the study based on them is most active in Japan. Some such studies are introduced in this short article, but it must be remembered that works introduced here are only a small part of similar works being done in Japan.

The author wishes that this short article may draw the attention of foreign seismologists to the study of historical earthquakes, and that the significance of studies based on old documents may be realised in the fields of modern geosciences, such as seismology and plate tectonics.

My sincere thanks must go to all persons who are concerned with the work of collecting, analysing and utilising data written in old documents.

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18. わが国における歴史地震の研究

地震研究所 宇佐美龍夫

地震予知との関連で，近年，古地震研究の重要性が広く世界的に認められるようになってきた．わが国では古地震史料の収集・整理，それに基く研究の歴史は古く，その成果は輝かしいものである．それはほとんど日本語で発表されており，外国人にとっては近づきがたい．

本報告は外国人に，わが国の古地震研究の概要を紹介するために記した．とくに第1表を付したのは，そのためである．まず，わが国における古地震史料の収集の歴史をのべ，ひきつづいて，収集史料にもとづく現代地震学的な研究のいくつかを紹介した．わが国の歴史地震の研究は旺んであるが，著者の力量不足もありその一部しか紹介し得なかったことについては御寛容を乞う次第である．