

On the Destructive Earthquakes in the Shinano-gawa Valley and those along the Japan Sea Coast.

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With Pls. XXIX-XXXI.

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1. *Earthquakes in the Shinano-gawa valley.* The Zenkoji earthquake of 1847 and the Sanjo earthquake of 1828 were two great historical shocks which occurred in the Shinano-gawa valley. I give next a short account of these disturbances and also of the Sado-Uzen earthquake of 1833, whose origin was in the Japan Sea.

2. *Zenkoji earthquake of 1847.* (See Fig. 1.) The great disturbance in the 4th year of Koka, generally known as the Zenkoji Earthquake, took place on May 8, 1847, at about 9 pm., and was one of the most violent shocks which ever occurred in Japan, the total number of the killed being not less than 8,600. The region of destructive motion of the earthquake, which shook strongly the northern part of the province of Shinano, and a portion of the province of Echigo, stretched from a place some

5 km to the east of the city of Takata, on the north, to the vicinity of the town of Matsumoto, on the south. The area, which was about 2,100 sq. km, with an average width of about 32 km, run in a SWS-NEN direction for a distance of 110 km, along the main course of the Shinano-gawa and its tributary, the Sai-gawa. On the south-east, it extended along the Chikuma-gawa, another tributary of the Shinano-gawa, to the vicinity of the town of Ueda; while, on the north-east, it reached almost to the boundary of the province of Shinano and the Naka-Uonuma and Higashi-Kubiki counties of Echigo.

The protuberance of the area in question on the north was probably due to the softness of the alluvial formation of the plain of Takata. The damage was, on the other hand, comparatively light in the mountainous region between Matsumoto and Ueda, partly on account of the scarcity of population.

The region, within which the greatest amount of damage was done, was about 480 sq. km in area, with an average width of 10 km, and extended for a distance of about 50 km from the vicinity of Iiyama on the north-east, to Shinmachi on the south-west, also branching out to the town of Inariyama on the south. This area, which was situated almost entirely on the west side of the Shinano-gawa and Sai-gawa, was made up mostly of tertiary and volcanic formations, and included amongst others, the following towns and villages:—

| | |
|---------------------|--|
| Nagano | Almost entirely destroyed. |
| Inariyama | 500 people killed. |
| Shiosaki-mura. | 1,400 (out of 1,600) houses destroyed. |
| Mure. | Almost entirely destroyed. |
| O-koma. | Do. |
| Nojiri. | 83 houses destroyed. |

The central axis of the area of the greatest damage extended from a little west of Iiyama, through the vicinity of Mure, to the valley tract of the *Sai-gawa* at some distance to the south-west of Nagano.

The city of Nagano suffered very severely, and was almost entirely destroyed by the shock and the subsequent fires; the number of the houses overthrown being, in the town or business quarters alone, 2350, of which 2194 were burnt. In Nagano and the suburbs, there were altogether 2,452 houses destroyed by fire, there being only 191 houses which escaped both shock and flame. The number of the killed, which could be ascertained, was about 2,400; this heavy amount of casualty being, in a great measure, due to the fact that the disastrous earthquake took place when multitude of people from different parts of the country were staying at Nagano, to attend the religious festivals held at the Zenkoji. The latter, which is one of the most sacred Buddhist temples in Japan, received no material damage from the earthquake, although the huge wooden structure must have been shaken tremendously, as was indicated by the throwing down of a heavy bronze bell, about 2.6 feet in diameter and 3.6 feet in height, hung in the front verandah. Fig. 3 shows the lower portion of the bell and the scar made on the corner post by the impact of the latter; while Fig. 2 gives a front view of the temple, which is in the same condition as before the great earthquake of 1847. Both of these pictures have been taken in 1908.

A special feature of the Zenkoji earthquake was the occurrence, among the mountains of tertiary formations, of landslips whose number was not less than 44,000. Amongst others, the southern side of Mount Iwakura, which is on the *Sai-gawa*, at a distance of about 12 km to the WSW of Nagano, was destroyed,

Fig. 1. Map showing the Areas of Destructive Motion of the Zenkoji and Sanjo Earthquakes.

- A.... Sanjo Earthquake of 1828. (Area of destructive motion).
 B.... Uzen and Sado Earthquake of 1833.
 C.... Zenkoji Earthquake of 1847. (The lightly shaded part indicates the area of destructive motion, and the densely shaded part the area of the greatest violence.)

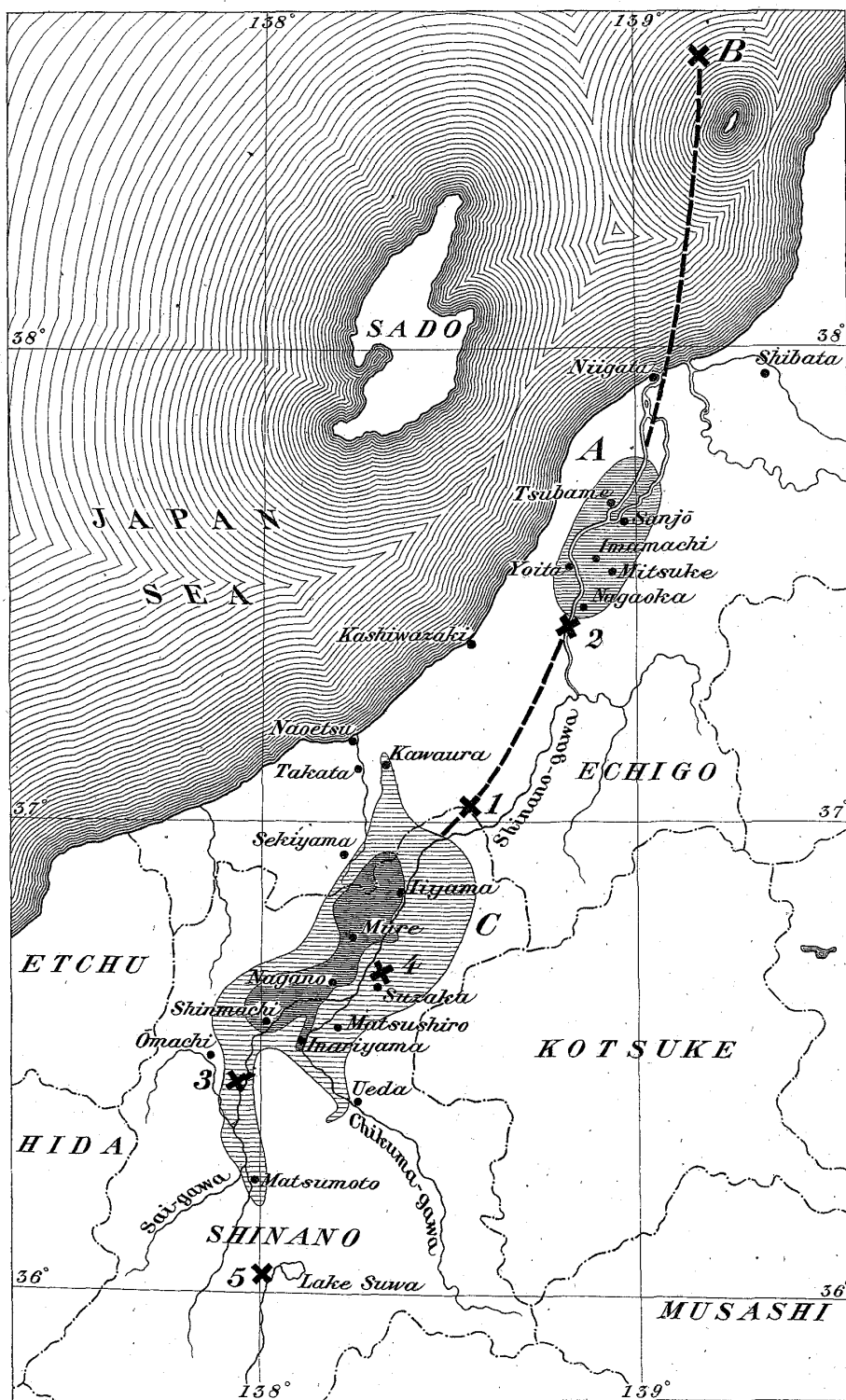


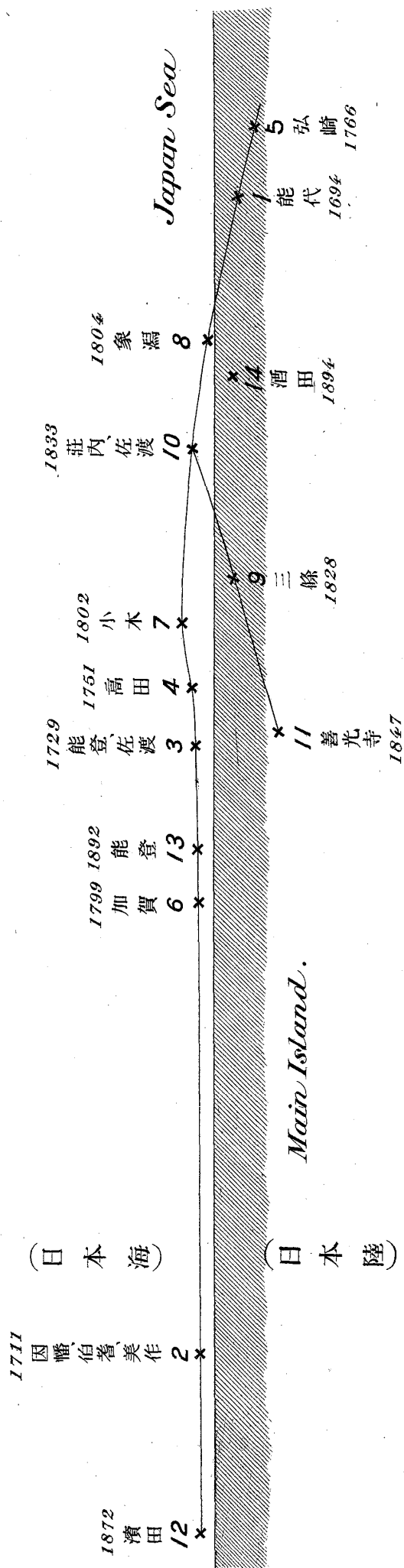


Fig. 2. The Zenkoji Temple. Front view.



Fig. 3. The Zenkoji Temple, showing the scar (indicated by a small cross x) made on the corner post by the bell thrown down on the occasion of the earthquake of 1847.

Fig. 4. Diagram indicating the Positions of the Destructive Earthquakes in the Shinano-gawa Valley and along the Japan Sea Coast.



- 1..... Noshiro, 1694.
- 2..... Inaba, Hoki, and Mimasaka, 1711.
- 3..... Noto and Sado, 1729.
- 4..... Takata, 1751.
- 5..... Hirosaki, 1766.
- 6..... Kaga, 1799.
- 7..... Ogi (Sado), 1802.
- 8..... Kisagata, 1804.
- 9..... Sanjo, 1828.
- 10..... Sado and Uzen, 1833.
- 11..... Zenkoji, 1847.
- 12..... Hamada, 1872.
- 13..... Noto, 1892.
- 14..... Sakata, 1894.

resulting in two gigantic landslips which completely blocked the course of the above-named river for 20 days, and formed a lake 34 km in length and 1 to 4.3 km in width. The water finally broke the two enormous dams, and flooded over the regions along the Sai-gawa and Shinano-gawa, sweeping away a large number of the houses which escaped the destruction from the shock. The loss of human lives was, however, small, as due preparations had previously been taken to meet the emergency.

3. Sanjo (Echigo) earthquake. The Sanjo earthquake took place on Dec. 18, 1828, at about 8 am. The area of destructive motion was an ellipse, 50×17 km, along the lower course of the Shinano-gawa; the most central point of the meizoseismal region being between the towns of Sanjo and Imamachi, at about $\varphi = 37^\circ 35' \text{ N}$, $\lambda = 138^\circ 56' \text{ E}$. (See Fig. 1.) The total amount of the casualties was 1,443 killed and 1,749 wounded, while the numbers of the houses entirely and partially destroyed were 9,808 and 7,276 respectively, beside the 1,204 burnt. Among the towns severely affected were Sanjo, Imamachi, Mitsuke, Yoita, Tsubame, and Nagaoka, the first four having been almost entirely destroyed by the shock and the subsequent fires.

4. Uzen and Sado earthquake. The earthquake of Dec. 7, 1833 (4th year of Tenpo), at about 4 pm., was destructive in the island of Sado and along the coast districts of the province of Uzen. The amount of the casualties was comparatively slight, the loss of lives being about 38, in Uzen, due to the *tsunami*, or tidal waves, which followed the earthquake. The centre of the latter was submarine, its approximate position being $\varphi = 38^\circ 35' \text{ N}$, $\lambda = 130^\circ 10' \text{ E}$. (See Fig. 1.)

5. Relation of the Zenkoji earthquake to the two others. The Sanjo earthquake took place 18 years 5 months earlier than

the Zenkoji earthquake, the meizoseismal zones of these two shocks running in nearly the same direction, namely, $N40^{\circ}E-S40^{\circ}W$. Further, the northern prolongation of the line connecting the centres of the two disturbances passes approximately through that of the Sado-Uzen earthquake. It is extremely probable that these three large earthquakes belonged to one and the same system, namely, the seismic zone formed by the Shinano-gawa valley and its northern prolongation. Apparently the stress reached a maximum limit along the whole extension of this zone, so that the Sanjo earthquake occurred first at the middle, followed 5 years later by the Sado-Uzen earthquake to the NEN, and again 13 years 5 months later by the Zenkoji earthquake to the SW; the two successive distances of the centres of the three earthquakes being each equal to about 115 km.

6. *Relation between the former destructive and the recent strong earthquakes in the Shinano-gawa valley.* As discussed in the *Bulletin*, Vol. I, No. 3, there were five strong semi-destructive earthquakes, which occurred along the Shinano-gawa, respectively in the years 1886, 1887, 1890, 1897, and 1899. The line connecting their centres has been taken as defining a seismic zone, which extends from the Koshi county in Echigo in the SW direction to the vicinity of Nagano, thence turning towards the south to the vicinity of the lake of Suwa. The approximate positions of the centres of these five earthquakes are indicated by the numerals 1, 2, 3, 4, and 5, in Fig. I. From the latter, it will be observed that the zone of the recent strong shocks is in reality identical with that of the historical destructive earthquakes. Further, the recent disturbances, Nos. 1 to 5, originated along the zone in question at those points, which are outside the area of destructive motion of the Sanjo earthquake and the meizo-

seismal region of the Zenkoji earthquake. This fact is fully in accordance with the principle that great seismic shocks never occur at one and the same centre.

7. Destructive earthquakes along the Japan Sea coast.

The following is the list of the larger destructive earthquakes,* which happened within the last $2\frac{1}{4}$ centuries, on or off the Japan Sea coast and along the Shinano-gawa zone :—

1. Noshiro Eqke (province of Ugo); June 19, 1694, at 7 A.M.
2. Inaba, Hoki, and Mimasaka Eqke; March 19, 1711.
3. Sado and Noto Eqke; Aug. 1, 1729. Accompanied by *tsunami*.
4. Takata Eqke (province of Echigo); May 21, 1751, at 2 A.M.
5. Hirosaki Eqke („ „ Mutsu); March 8, 1766, at 6 P.M.
6. Kaga Eqke; June 29, 1799. Accompanied by *tsunami*.
7. Ogi Eqke (Island of Sado); Dec. 9, 1802, at 2 P.M.
8. Kisagata Eqke (provinces of Uzen and Ugo); July 13, 1804, at 10 P.M.
9. Sanjo Eqke (Echigo); Dec. 18, 1828, at 8 A.M.
10. Sado and Uzen Eqke; Dec. 7, 1833, at 4 P.M. Accompanied by *tsunami*.
11. Zenkoji Eqke (Shinano and Echigo); May 8, 1847, at 9 P.M.
12. Hamada Eqke (Iwami); March 14, 1872, in the evening.
13. Noto Eqkes; Dec. 9 and 11, 1892.
14. Sakata Eqke (Uzen and Ugo); Oct. 22, 1894, at 5 P.M.

Of the above 14 earthquakes, Nos. 1, 4, 5, 8, 9, 10, 11, 12, and 14 were much larger than the remaining five. Again, the five earthquakes of Nos. 1, 5, 9, 11, and 14 originated inland, while the 7 others, namely, Nos. 3, 4, 6, 7, 10, 12, and 13, originated under the Japan Sea. The origins of the two remaining earthquakes, Nos. 2 and 8, were probably also submarine. The relative

* Hokkaido and Formosa excepted.

positions of the origins of the different earthquakes are diagrammatically illustrated in Fig. 4, (Pl. XXXI.)

The 14 earthquakes tabulated above may be divided, so far as their time distribution is concerned, into the following 5 groups :—

Group I.

| | Year | Interval |
|--|------|---|
| No. 1. Noshiro Eqke. | 1694 | }17 ^{years}182215 |
| No. 2. Inaba, Hoki, and Mimasaka Eqke. . . | 1711 | |
| No. 3. Noto and Sado Eqke. | 1729 | |
| No. 4. Takata Eqke. | 1751 | |
| No. 5. Hirosaki Eqke... | 1766 | |

Group II.

| | | |
|-----------------------------|------|--------------------|
| No. 6. Kaga Eqke. | 1799 | }32 |
| No. 7. Ogi „ | 1802 | |
| No. 8. Kisagata „ | 1804 | |

Group III.

| | | |
|-------------------------------------|------|---------------------|
| No. 9. Sanjo Eqke. | 1828 | }514 |
| No. 10. Sado and Uzen Eqke. | 1833 | |
| No. 11. Zenkoji Eqke... | 1847 | |

Group IV.

| | |
|------------------------------|------|
| No. 12. Hamada Eqke. | 1872 |
|------------------------------|------|

Group V.

| | | |
|----------------------------|------|----------|
| No. 13. Noto Eqke. | 1892 | }2 |
| No. 14. Sakata „ | 1894 | |

The five earthquakes in Group I occurred with a tolerable regularity, the average interval being 18 years. On the other hand, the three earthquakes in Group II as well as the three in

Group III occurred at short intervals ranging from 2 to 14 years; while the interval between the 1st earthquake of Group II and the last of Group I was 33 years, and that between the 1st earthquake of Group III and the last of Group II was 24 years. Again, the time interval between the earthquake of Group IV and the last one of Group III was 25 years. These facts seem to favour the supposition that the three earthquakes of Sanjo, Sado-Uzen, and Zenkoji really belonged to one and the same seismic zone both geographically and in time distribution, as explained in § 5. All the other earthquakes, with the exception of the Sakata earthquake, belonged to the Inner Seismic Zone, which runs nearly parallel to the concave side of the Japanese islands.* The Sakata earthquake probably belonged to another system.†

* See the "Bulletin of the Imp. Earthquake Inv. Com.", Vol. I, No. 2.

† The Sakata, Riku-U, and Hachinohe earthquakes have been ably studied by Professors Koto, Yamasaki, and Imamura, respectively.