

(62) Dec. 3rd, 1911; 3.16 am. At Maebashi, the detonation shook at 3.16 am the houses slightly, there being some precipitation of ashes in the early morning. From Naganohara, where the sound was so intense as to almost break the glass panes of doors and windows, the large masses of black smokes arising from the mountain top were observed to be mixed with bright sparks of fire. The detonation was perceived at 3.24 am at the meteorological observatory of Fushiki, being also noticed at Higashi-Mizubashi and Namekawa in the Naka-Shinkawa county of Etchu.

CHAPTER IV. AREAS OF PROPAGATION OF THE VOLCANIC DETONATIONS.

19. Nature of detonations. Volcanic detonations consist entirely in the waves of the air caused by the sudden explosions, whose propagation is greatly modified by the winds, and also to an extent by the topography, but which have nothing to do with the earthquake movements which attend them. Thus, it happened that the recent Asama-yama sounds were often heard to the distance of nearly 300 km, although the shakings of the ground were not sensible even in the immediate vicinity of the volcano. On the other hand, the seismograph at Nagano, which is only at a distance of 40 km from the latter, recorded a great number of the earthquakes (unfelt) accompanying the explosions, but the volcanic sounds were very rarely heard at that city.

The detonations were often felt as strong movements at Komoro and some other places at the base of the mountain, knocking out the sliding doors and shoji out of the grooves. Even in these cases, however, the houses had only their upper parts strongly shaken, as if struck by violent winds, while the

ground remained calm. This fact, also noticed on the occasion of the great eruption of the Fuji-san in the Hoei period (1707), indicates very clearly that the detonations are aerial disturbances.

It sometimes happened that the detonations accompanying the Asama-yama explosions were not perceived at all at Ashino-taira situated on the SW slope of the mountain, while they were heard at more distant places, a phenomenon due to the formation of sound shadows. Thus, the outburst of Feb. 13th, 1911, at 10.25 pm, was accompanied by detonations which were heard at Maebashi (radial distance=50 km), but not at Ashino-taira. Again, the detonation on Jan. 30th, 1911, at 9.38 am, was heard at Ashino-taira as a faint rumbling sound like that of distant thunders which caused no rattling of the doors and windows; while, at the same time the houses at the town of Iwamurata, situated 16 km to the S20°W of the volcano, were shaken strongly for a considerable length of time.

I describe next the effects on the barographs, and then, for a number of the more typical cases of the explosions, the areas within which the detonations were heard.

20. Barograph record. The explosion of Dec. 7th, 1909, which was the strongest among the numerous recent outbursts, left distinct traces on the barographs at the different stations, (Figs. 18 and 19), as follows:—

TABLE IX. THE ASAMA-YAMA EXPLOSION OF DEC. 7TH, 1909:
EFFECTS ON THE BAROGRAPHS.

Station.	Pressure Change caused by Explosion.
Maebashi.	1.5 mm rise, followed by 0.4 mm fall.
Yokohama.	Slight.

Fig. 18. Barograph Record obtained at the Meteorological Observatory of Yokosuka, showing the Effect due to the Explosion of the Asama-yama on Dec. 7th, 1909.

A=Sudden barometric rise due to the atmospheric waves of the Explosion.

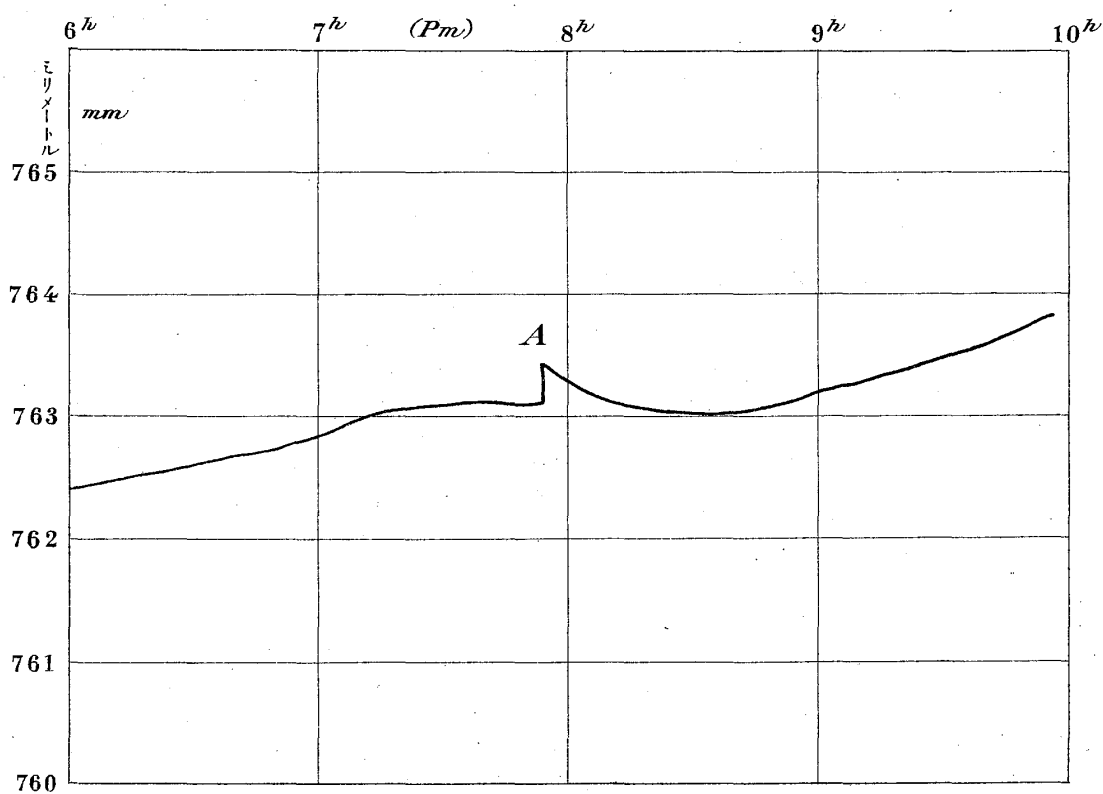
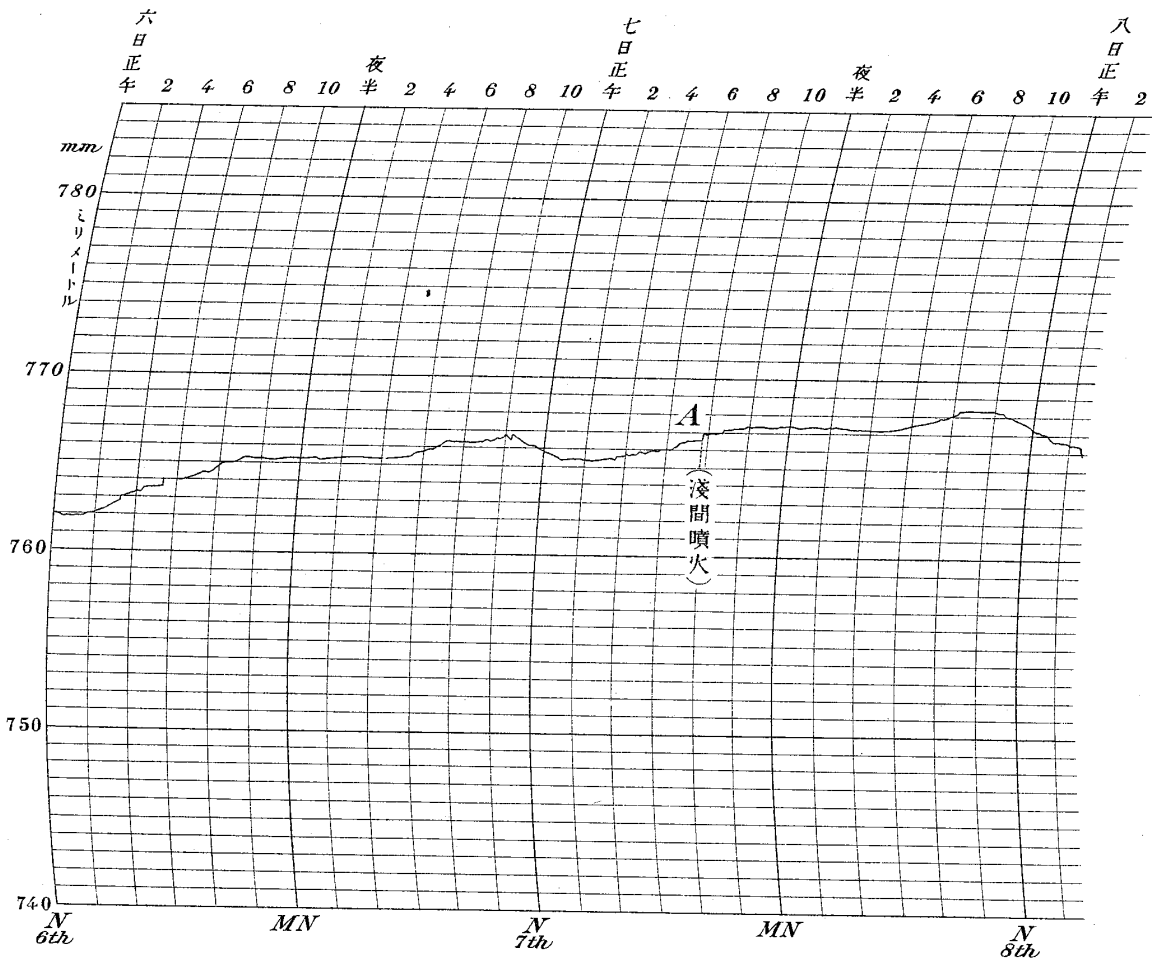


Fig. 19. Barograph Record obtained at the Central Meteorological Observatory, Tokyo, showing the Effect due to the Asama-yama Explosion on Dec. 7th, 1909.

A=Sudden barometric rise due to the atmospheric waves of the Explosion.



Station.	Pressure Change caused by Explosion.
Yokosuka.	0.4 mm sudden rise.
Utsunomiya.	Slight.
Tokyo (Central Met. Obs.)	Rise and fall together amounted to 0.3 mm.
Tsukuba-san (Top)	0.5 mm rise; 0.4 mm fall.
,, (Base)	Rise and fall together amounted to 1.8 mm.
,, (Mid-slope)	No change.

Thus it will be seen that the explosion affected the barographs to an extent of single amplitude of nearly 0.5 mm even at the radial distance of 140 to 160 km; while the daily noon-gun discharge in Tokyo leaves no trace even on the barographs at the Central Meteorological Observatory situated in the neighbouring ground. These facts show the enormity of the wave energy of the Asama-yama explosion, and it seems likely that the sudden pressure change caused the extremely minute movements forming the introductory portion of the "sound tremor," or the vibrations of the ground occurring at the arrival of the air disturbances. As shown in the barograms obtained at Yokosuka, Tokyo, and Maebashi, the first change in the pressure was a rise, followed by a fall; this being a consequence of the outward push of the air around the mountain at the moment of the explosion. It is unnecessary to add that the air waves of the explosions, causing disturbances on the barographs, may not always be accompanied by audible sounds.

21. Sound and ash-precipitation areas of strong explosion of Dec. 7th, 1909, at 7.45.07 pm. (Fig. 20.) In Tokyo the detonation was loud and similar to that caused by a powder explosion, shaking the houses strongly, although unattended by

movements of the ground. In the N. Saku county (Shinano) at the southern and south-eastern parts of the base of the volcano, the sound shock was so violent that, in many cases, the window panes were broken, the doors and shoji broken or thrown out of their grooves, the kamoi were knocked down, etc. At the town of Karuizawa, one woman fainted in consequence of the terrible noise of the explosion.

The sound area, whose extreme distances from the Asama-yama were 180 km toward the S, and 270 km toward the NE, respectively to the coast of Suruga and the Sendai Bay, did not extend westwards at all; the detonation having entirely failed to be perceived at the city of Nagano, 40 km to the NW, and at the town of Ueda, 24 km to the W, from the mountain. That the sound was not heard in the boundary districts of the provinces of Sagami, Kai, Suruga, and Izu, might probably be due to the obstruction presented by the Fuji-yama to the propagation of the air shocks. Outside the above mentioned principal area the sound was heard at Iwamura (Ena county) and Neo-valley (Motsu county), both in the province of Mino, respectively at 194 and 152 km to the SW of the volcano.

The following table gives, for the different places, the wind direction and velocity and the cloud amount at 6, 8, and 10 pm, on the day of the eruption.

TABLE X. WIND DIRECTION AND VELOCITY AND CLOUD AMOUNT, AT 6, 8, AND 10 PM, ON DEC. 7TH, 1909.

Station.	6 pm.			8 pm.			10 pm.		
	Wind.		Amount of Cloud.	Wind.		Amount of Cloud.	Wind.		Amount of Cloud.
	Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.	
Choshi	N	m/s 8.8	2	—	—	—	WNW	m/s 3.2	0
Maebashi	N	6.3	1	—	—	—	NNW	8.3	10
Kumagai	NW	2.5	0	—	—	—	W	1.7	2
Mito	N	2.4	0	NNW	2.5	0	NNW	0.9	0
Tokyo	W	1.8	2	WSW	1.8	1	W	3.0	0
Yokohama	SW	2.7	0	—	—	—	W	2.2	0
Yokosuka	NNE	0.6	10	—	—	—	NNE	0.6	7
Utsunomiya	NNE	2.9	0	—	—	—	—	0.4	3
Nagano	N	0.7	0	—	—	—	NW	2.7	0
Niigata	SSW	1.9	10	—	—	—	SE	3.1	10
Ashio	N	1.6	2	—	—	—	W	3.8	0
Iida	W	1.0	1	—	—	—	—	0.0	1
Kofu	NW	5.8	0	—	—	—	—	0.2	0
Matsumoto	—	0.1	0	—	—	—	—	0.0	0

The area of the precipitation of the ashes was a lens-like zone, about 190 km in length, stretching from the Asama-yama, as the apex, in a general direction of S82°E, which reached the Pacific coast at the Kajima county, in the province of Hitachi. This zone, which was at first so narrow that the town of New Karuizawa was not included in it, gradually diverged with the radial distance, reaching the maximum width of 47 km in the vicinity of Kumagai and Konosu, thence again narrowing. In the immediate neighbourhood of the Asama-yama, the amount of the precipitation was about 0.2 mm at Karuizawa (old town) and 0.1 mm at the towns of Sakamoto and Usui; while, in the province of Hitachi, the ashes, presenting the appearance of thin frost, were only recognized on the trees and roofs. If we assume the mean amount of the precipitation within the above mentioned

area, which covered about 500 sq. km, to be 0.05 mm, the total volume of the ashes would be roughly 25,000 cubic metres, or nearly 30 metres cube.

The following table gives for the three places of Kumagai, Yuki, and Tsukuba, the time observations relating to the precipitation of the ashes:—

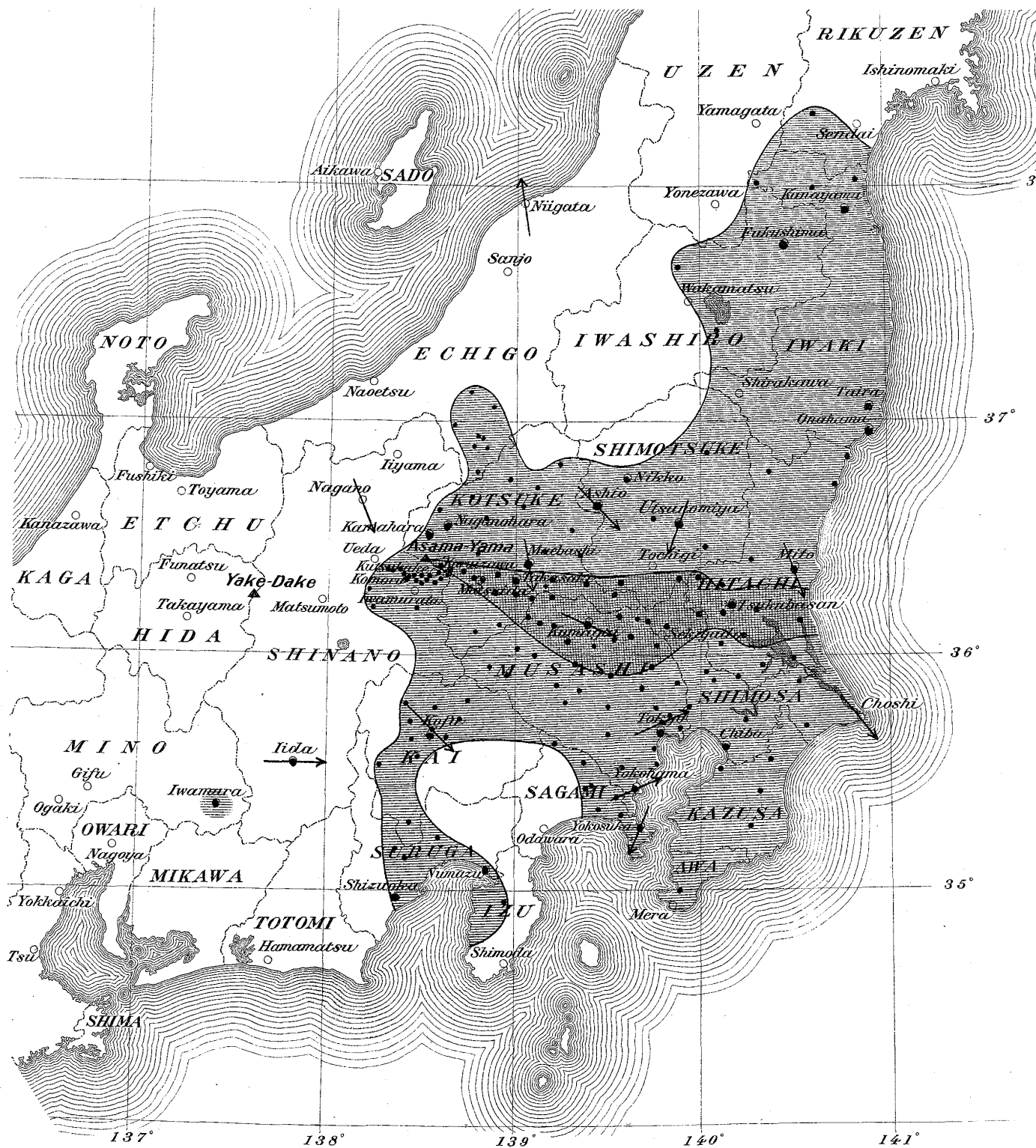
Place.	Distance from Asama.	Time difference between the detonation and the commencement of the precipitation.	Time interval taken by the ashes in traversing the distance.*
Kumagai.	80 km	1 ^h 55 ^m	1 ^h 59 ^m
Yuki.	122 „	1 15	1 21
Tsukuba.	145 „	1 00	1 07

According to the above table, the ashes were carried from the volcano with a mean velocity of about 80 km per hour, or 22 metres per sec. The actual surface winds at Nagano, Maebashi, Kumagai, etc., were at the time of the explosion generally north-westerly, with a velocity less than 5 metres per sec., except at Nagano, where it reached 8.7 metres per sec. The precipitation of the ashes at the different places probably lasted from 20 min. to 2 hours. In Fig. 20 are also indicated, for the different stations, the wind direction at 8 pm, or the mean of the directions at 6 and 10 pm, on the 7th of December. It will be observed that the general wind direction was NNW in the entire neighbourhood of the ash-precipitation area, which extended from the Asama-yama, toward the east slightly south, to the vicinity of Chosi and Kajima, and to which the sound area may be regarded as being roughly symmetrical.

* This is the interval between the time of occurrence of the explosion at the Asama-yama and the moment when the ashes began to fall at the different places.

Fig. 20. Sound and Ash-precipitation Areas of the Asama-yama Eruption of Dec. 7th, 1909; 7.45.07 pm.

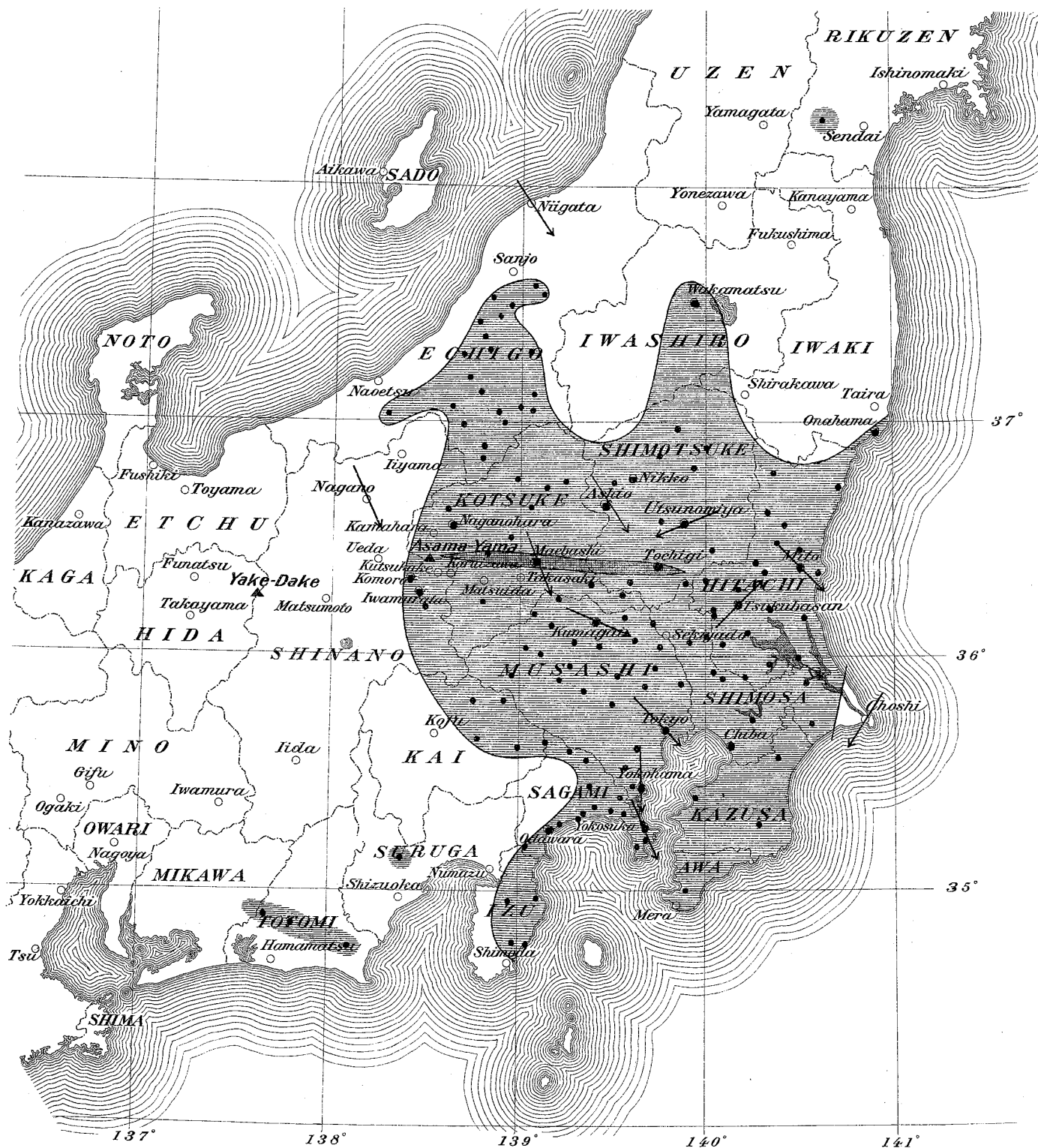
Sound-area is shaded red (thin).
 Ash-area " " " (deep).
 Wind Direction at the time of Eruption is indicated by a red arrow.
 Places where Detonation was perceived are indicated by red dots.



Boundary of provinces.

Fig. 21. Sound and Ash-precipitation Areas of the Asama-yama Eruption of Dec. 2nd, 1910; 8.20.36 pm.

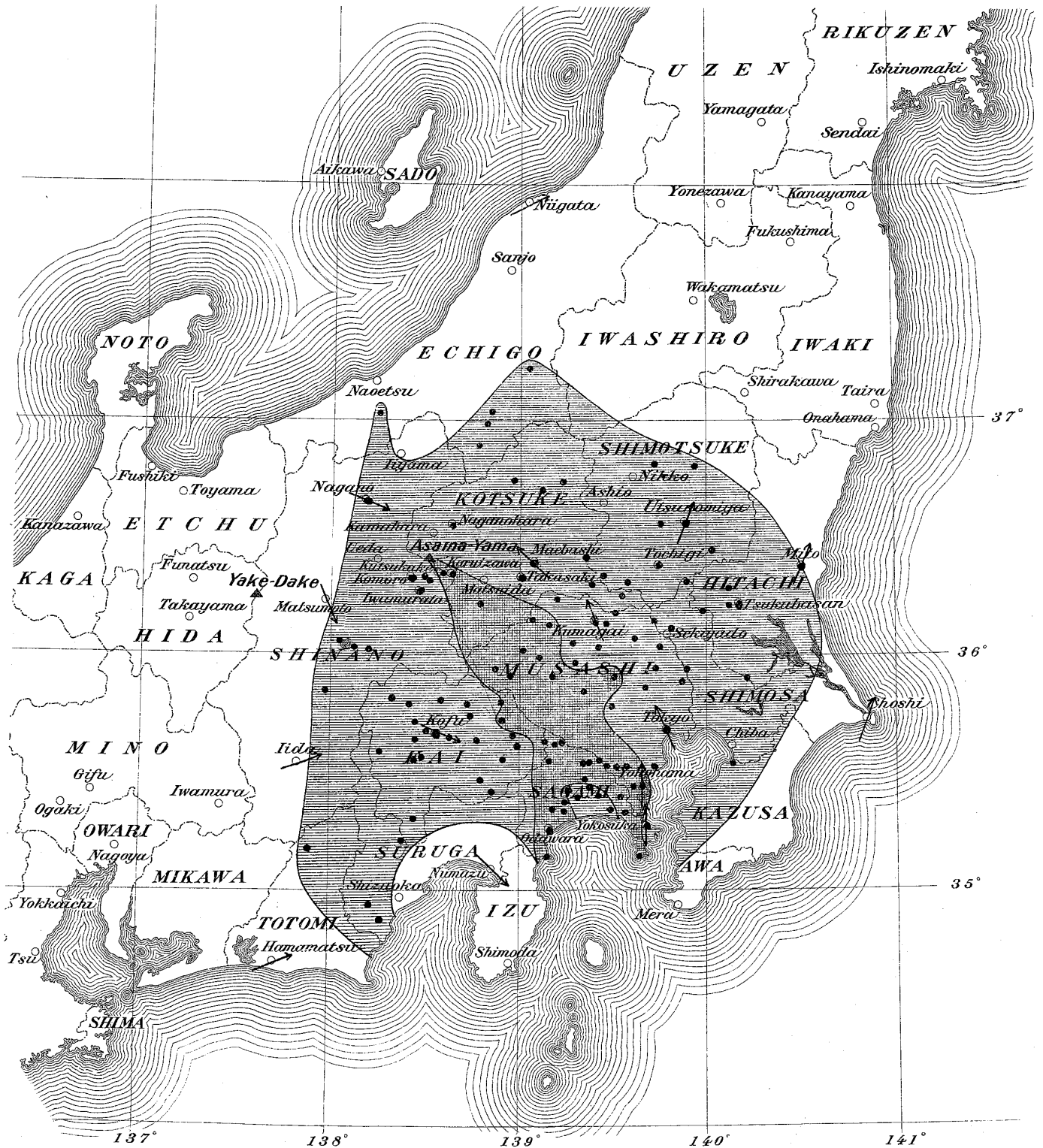
Sound-area is shaded *red* (thin).
 Ash-area " " " (deep).
 Wind Direction at the time of Eruption is indicated by a *red* arrow.
 Places where Detonation was perceived are indicated by *red* dots.



Boundary of provinces.

Fig. 22. Sound and Ash-precipitation Areas of the Asama-yama Eruption of May 8th, 1911; 3.27.58 pm.

Sound-area is shaded red (thin).
 Ash-area " " " (deep).
 Wind Direction at the time of Eruption is indicated by a red arrow.
 Places where Detonation was perceived are indicated by red dots.



Boundary of provinces.

Sound Areas of the Asama-yama Eruptions in Dec. 1910.

Places where Detonation was perceived are indicated by red dots.
Sound area is shaded red.

Fig. 24. Eruption on the 16th; 8:05 am.

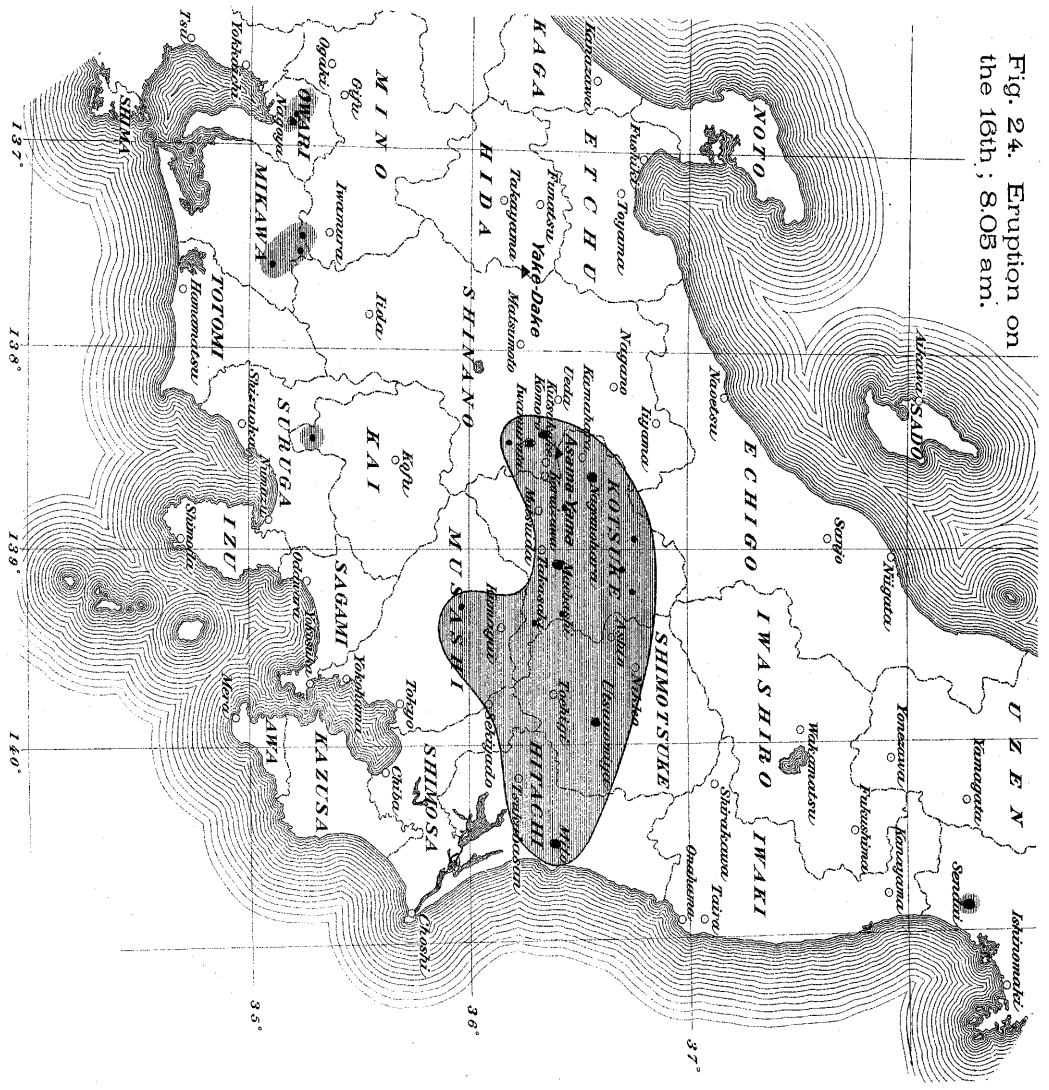
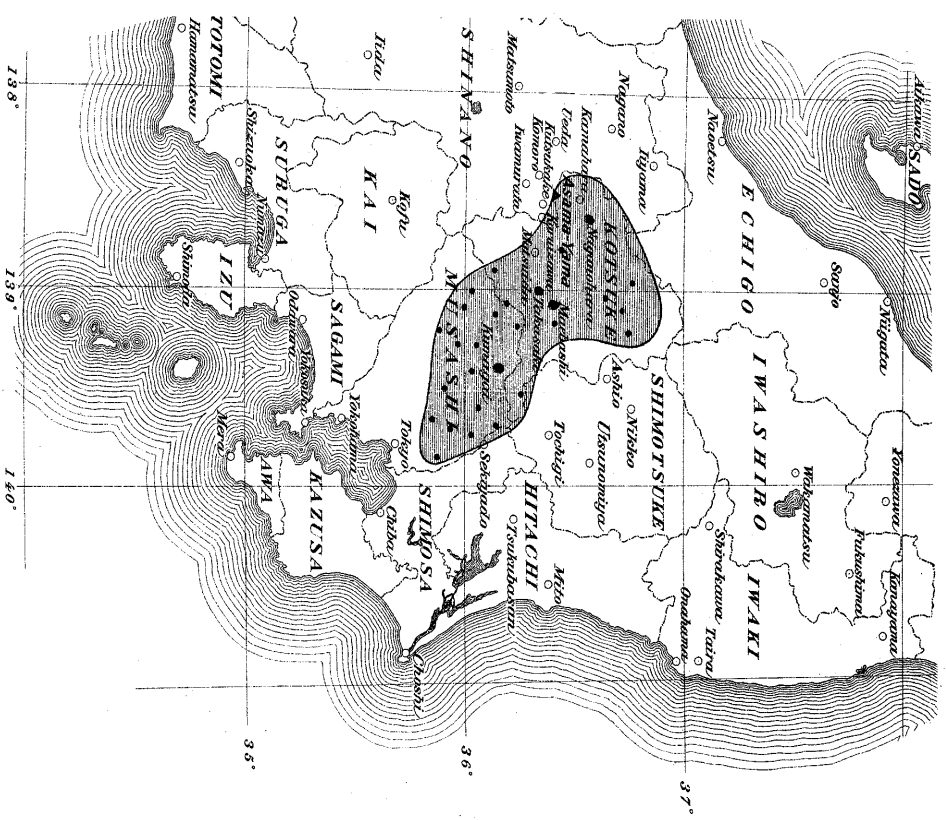


Fig. 23. Eruption on the 15th; 5:01 pm.



Boundary of provinces.

Sound Areas of Asama-yama Eruptions of Jan. 18th, 1911.

Places where Detonation was perceived are indicated by red dots. Sound-area is shaded red.

Fig. 25. Eruption at 5.20.58 pm.

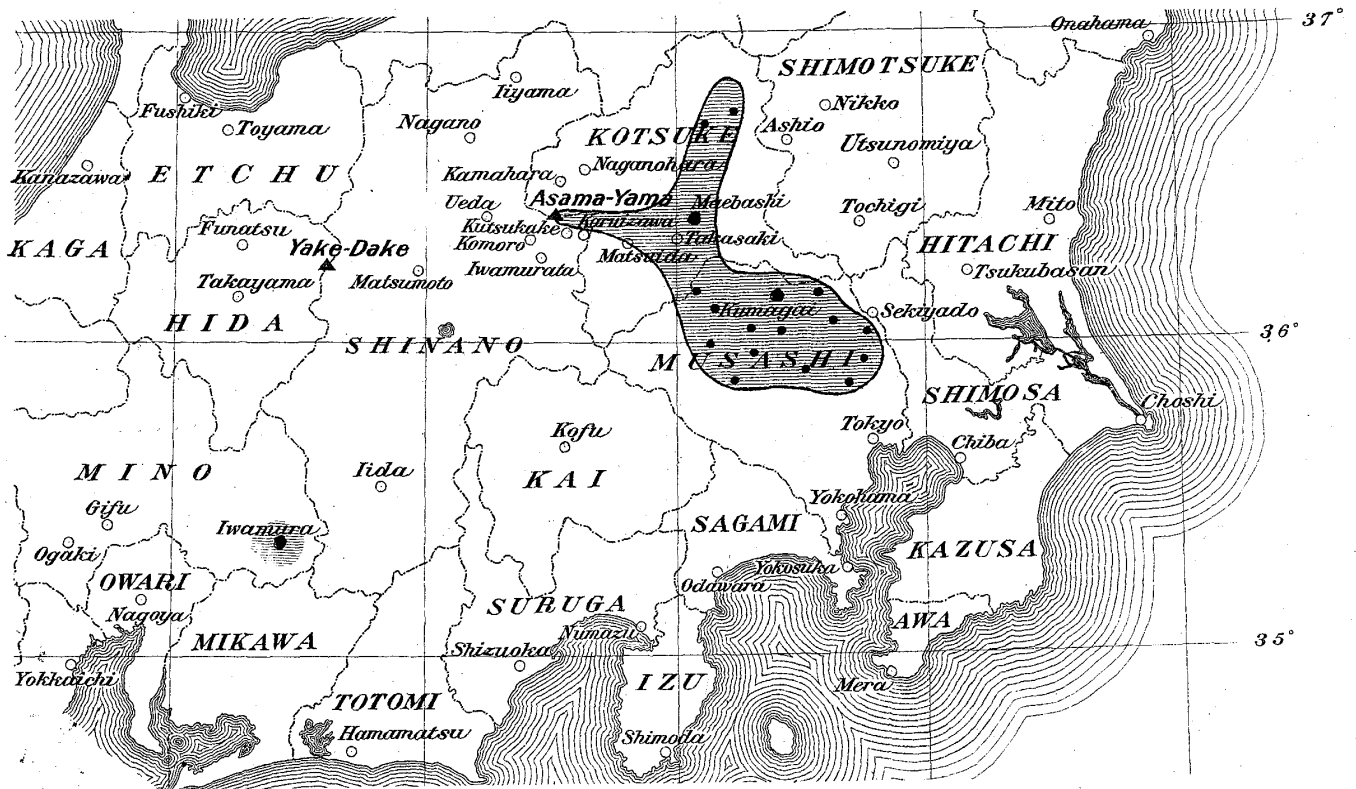


Fig. 26. Eruption at 9.27.49 pm.



22. Sound and ash-precipitation areas of strong explosion of Dec. 2nd, 1910, at 8.20.36 pm. (Fig. 21.) The area extended on the E. and SE sides to the Pacific, excepting a small neighbourhood of Choshi, and on the N. along the valley of the Shinano-gawa, almost to the coast of the Japan Sea. It included the provinces of Kotsuke, Musashi, Awa, Kazusa, Shimosa, Hitachi, Shimotsuke, Iwashiro (central part), Echigo (S. part), Izu (NE part), Sagami (excepting its W. part), Kai (NE part), and Shinano (E. small part); the extreme distances from the Asama-yama being 220 km toward the NNE (coast of Iwaki) and also toward the SE (E. coast of Kazusa), 190 km toward the SSE (SE coast of Izu), and 140 km toward the NNW (vicinity of Sanjo, in Echigo). Outside this area, the sound was heard at the following three districts:—

	Distance and Direction from the Asama-yama.
Sakunami-mura (near Sendai, Rikuzen).....	280 km, toward NE.
City of Shizuoka.	140 ,, , ,, S.
S. part of Totomi.....	185 ,, , ,, SSW.

The sound had practically no propagation toward the W., not having been perceived at all even at Ueda and Nagano, respectively 24 km toward the W. and 40 km toward the NW, from the mountain. The area of precipitation of the ashes consisted in a narrow zone extending due eastwards for a distance of only 100 km to the vicinity of Tochigi. The wind and cloud observations in the evening of the explosion at the different meteorological stations in Central Japan were as follows:—

TABLE XI. WIND DIRECTION AND VELOCITY AND CLOUD AMOUNT.
AT 6, 8, 9, AND 10 PM, ON DEC. 2ND, 1910.

Station.	6 ^h pm.			8 ^h pm.			9 ^h pm.			10 ^h pm.		
	Wind.		Amount of cloud.	Wind.		Amount of cloud.	Wind.		Amount of cloud.	Wind.		Amount of cloud.
	Direc- tion.	Veloc- ity.		Direc- tion.	Veloc- ity.		Direc- tion.	Veloc- ity.		Direc- tion.	Veloc- ity.	
Choshi	NE	^{m/s} 12.2	10	—	^{m/s} —	—	—	^{m/s} —	—	NNE	^{m/s} 10.1	10
Maebashi	NNW	17.9	5	—	—	—	—	—	—	NNW	9.0	0
Kumagai	NW	6.7	10	—	—	—	WNW	7.9	9	W	5.8	7
Mito	NW	2.8	10	NW	2.6	10	NW	1.9	10	NW	1.2	10
Tokyo	NNW	3.5	10	NW	2.4	10	NNW	3.0	10	NNW	3.7	10
Yokohama	N	5.2	10	—	—	—	—	—	—	N	4.7	10
Yokosuka	NNW	4.4	10	NNW	4.0	—	—	—	—	NNW	4.5	10
Tsukuba	SSW	3.2	10	SW	3.6	10	—	—	—	WSW	11.6	9
Utsunomiya	E	1.9	3	—	—	—	—	—	—	NE	0.9	2
Nagano	NE	0.5	7	—	—	—	—	—	—	WNW	1.0	10
Niigata	NNW	6.2	10	—	—	—	—	—	—	NW	4.3	10
Ashio	NW	6.2	0	—	—	—	—	—	—	NNW	6.7	0

Thus the wind directions at the different places, at 6 to 10 pm, were, with the exceptions of Choshi, Utsunomiya and Tsukuba, NNW, NW, or WNW, i.e., the general course of the *surface* air current was nearly a NNW one, crossing obliquely the Main Island from Sado and Echigo toward the Kazusa-Awa peninsula. As, however, the zone of precipitation of the ashes extended toward the east, it appears that the wind in the higher atmospheric region was different in direction from the surface winds and was westerly. Again, the form of the sound area is approximately symmetrical with respect to the W-E ash-precipitation zone, but indicates no such relation at all with respect to the line drawn through the Asama-yama parallel to the general course of the surface winds, or a line in the SSE direction.

The highest wind velocity of 17.9 m/sec. was observed at Maebashi; the velocity at all the other stations were below 6.7

m/sec. With regard to the cloudiness, the two provinces of Kotsuke and Shimotsuke indicated the amount of 0 to 5, while all the other provinces were covered to the amount of 7 to 10.

23. Sound and ash-precipitation areas of strong eruption of May 8th, 1911, at 3.27.58 pm. The sound area (Fig. 22), about 240 km in the NS as well as in the EW dimension, included the entire provinces of Kotsuke, Musashi, Sagami, and Kai; the E. half of Shinano; the S. portions of Echigo; Shimotsuke, except the NE portion; the SW part of Hitachi; Shimosa, except the E. part; the W. part of Kazusa; the W. part of Suruga; and the NE part of Totomi. The detonation was not perceived in the province of Izu and also in the SE part of Suruga, due probably to the shadow effect of the Fuji-yama. It may be noted that the sound area in question was smaller, and situated more westwards, than those of the two other strong disturbances, namely, the explosions of Dec. 7th, 1909, and Dec. 2nd, 1910.

The area of precipitation of ashes, about 50 km in mean width, extended from the Asama-yama in a SE direction to the coasts of Sagami and Musashi, including the vicinity of Kutsukake and Karuizawa in Shinano, the SW part of Kotsuke, the SW half of Musashi, a small E. portion of Kai, and a large portion of Sagami. This zone may be considered as forming an axis about which the sound-area was approximately symmetrical.

Table XII gives the wind direction and velocity and the cloud amount at the different meteorological stations on May 8th, 1911, at 2, 3, 4, and 6 pm. For the 2nd class stations, where the meteorological observations were made only at the 2 and 6 pm, the wind direction at the time of the explosion, namely, 3½ pm, on the 8th, may be assumed to be equivalent to the mean of those at the two former hours.

TABLE XII. WIND DIRECTIONS AND VELOCITY AND CLOUD AMOUNT,
AT 2, 3, 4, AND 6 PM, ON MAY 8TH, 1911.

Station.	2 pm.			3 pm.			4 pm.			6 pm.		
	Wind Direc- tion.	Wind Velo- city.	Cloud Amount.	Wind Direc- tion.	Wind Velo- city.	Cloud Amount.	Wind Direc- tion.	Wind Velo- city.	Cloud Amount.	Wind Direc- tion.	Wind Velo- city.	Cloud Amount.
Niigata *	WSW	12.0	0	—	—	—	—	—	—	WSW	6.4	0
Nagano *	W	6.3	0	—	—	—	—	—	—	N	2.8	0
Matsumoto *	NW	3.9	0	—	—	—	—	—	—	N	3.7	5
Iida *	SW	7.8	8	—	—	—	—	—	—	W	6.2	10
Maebashi *	SSE	5.8	5	—	—	—	—	—	—	ESE	2.4	4
Utsunomiya *	SSW	7.7	2	—	—	—	—	—	—	S	4.4	4
Ashio *	NE	8.5	7	—	—	—	—	—	—	W	5.4	2
Mito	SSW	7.3	0	SSW	7.2	1	SSW	7.9	0	SSW	6.2	5
Choshi *	SSW	6.9	7	—	—	—	—	—	—	SSW	8.6	10
Tokyo	SSE	8.3	1	SSE	9.0	3	SSE	7.9	8	S	6.5	9
Kumagai **	S	8.3	1	—	—	—	SSE	7.7	—	SE	4.1	10
Yokohama *	S	7.7	4	—	—	—	—	—	—	S	5.3	10
Yokosuka *	S	5.1	10	—	—	—	—	—	—	S	5.4	10
Numazu *	W	6.0	9	—	—	—	—	—	—	NNW	3.4	10
Kofu *	SW	6.0	2	—	—	—	—	—	—	N	3.8	10
Hamamatsu *	WSW	6.9	10	—	—	—	—	—	—	W	7.3	10

* 2nd class meteorological stations, or those making 4-hourly observations.

** Kumagai, at 3.30 pm: Direction SSE, Velocity 6.9 m/s.

From Table XII and Fig. 22, it will be noted that the wind at the time of the explosion was, in the eastern half of the sound-area, generally southerly, namely, S (Yokohama, Yokosuka), SSE (Tokyo, Kumagai), SE (Maebashi), or SW (Utsunomiya and Mito, and also at Choshi); while, within and about the western boundary of the area, it was generally westerly, namely, WSW (Hamamatsu, Iida, Niigata), WNW (Nagano, Kofu), NW (Numazu), or NNW (Matsumoto). Further, the velocity of the southerly winds at Tokyo, Mito, and Kumagai was from 6.9 to 9 m/sec. It is thus clear that in the present instance the detonation was propagated towards the SE from the mountain even against the contrary *surface* winds of moderate intensity.

24. Sound areas of eruptions on Dec. 15th and 16th, 1910, and on Jan. 18th, 1911. Beside the three strong explosions above mentioned the following eight were typical and had more or less extensive sound areas:—

- | | |
|---------------------------------|----------------------------------|
| (i) Dec. 15th, 1910; 5.01 pm. | (v) Jan. 18th, 1911; 9.27.49 pm. |
| (ii) „ 16th, „; 8.05 am. | (vi) April 3rd, „; 1.52.30 „ |
| (iii) „ 25th, „; 8.45.30 pm. | (vii) Oct. 22nd, „; 3.46.04 am. |
| (iv) Jan. 18th, 1911; 5.20.58 „ | (viii) May 31st, 1909; 11.25 pm. |

The sound areas of these eight explosions are shown in Figs. 23 to 30, (Pls. XVI-XXI); those of (i), (ii), (iv), and (v) resembling each other, and extending from the Asama-yama, as the apex, toward the SE or the E.

(i) includes Kotsuke and the northern half of Musashi, with the extreme distance of 140 km from the Asama-yama, toward the ESE.

(ii) includes a part of the N. and S. Saku counties in Shinano, the SW half of Shimotsuke, the NE part of Musashi, the NW part of Shimosa, and the central part of Hitachi; the extreme length being 185 km toward the due E. Outside this area, the sound was also heard at the following 4 places;—

Sendai and vicinity	290 km, toward the NE.
SW end of Kai.....	125 „ „ „ S.
N. part of Mikawa.....	170 „ „ „ S40°W.
Nagoya, Inazawa, and vicinity	200 „ „ „ S50°W.

(iv) includes a part of Kotsuke and the N. part of Musashi, with the extreme distance of 125 km toward the ESE. Outside this area, the sound was heard also at Iwamura, Ena county, Mino, at a distance of 152 km toward the SW.

(v) includes a part of the N. and S. Saku counties, Shinano, the central and W. parts of Kotsuke, a large part of Musashi, the SE part of Shimotsuke, the SW part of Hitachi, and the NW

part of Shimosa, with the extreme distances of 180 km toward the E. and of 160 km toward the SE. The sound was heard on this occasion also at Iwamura in Mino.

As shown in Table XIII, the wind velocity was always below 5 or 6 m/s except in the case of (i), when it reached 11 m/s at Maebashi. The wind directions were as follows:—(i), N or NNW at Maebashi, Yokohama, Ashio, Nagano, etc., and NE, NNE, or E at Tokyo, Mito, and Utsunomiya. (ii), NW or NNW, except at Nagano (SW), Ashio (SE), and Utsunomiya (E). (iv), N or NW at Maebashi, Mito, Nagano, and Utsunomiya, NNE or NE at Tokyo and Yokohama, and S at Kumagai and Ashio. (v), mostly NNE or NW. In these cases, therefore, the general wind direction at the different places in the sound areas was northerly or north-westerly; while the sound areas most extended approximately toward the east or south-east, wanting, however, as in the cases of the strong explosions of Dec. 7th, 1909, and of Dec. 2nd, 1910, a symmetry about a line drawn through the volcano parallel to the prevailing wind direction.

TABLE XIII. WIND DIRECTION AND VELOCITY AT THE DIFFERENT STATIONS ON THE OCCASIONS OF THE EXPLOSIONS OF DEC. 15TH AND 16TH, 1910, AND OF JAN. 18TH, 1911.

Station.		Tokyo.	Kumagai.	Maebashi.	Mito.	Yokohama.	Nagano.	Ashio.	Utsunomiya.
Hour.									
December 15th, 1910.									
5 pm.	Direction	NE	—	—	ENE	—	—	—	—
	Velocity	2.0	—	—	1.8	—	—	—	—
6 pm.	Direction	NE	—	N	NNE	NNW	N	NNW	E
	Velocity	1.8	0.0	11.0	2.9	1.7	2.8	2.4	2.2

Hour.	Station.	Tokyo.	Kuma- gai.	Mae- bashi.	Mito.	Yoko- hama.	Nagano.	Ashio.	Utsuno- miya.
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December 16th, 1910.

6 am.	Direction	NW	NW	NNW	NNW	NNW	—	—	—
	Velocity	2.8	1.7	8.1	1.8	1.4	—	—	—
8 am.	Direction	NW	—	—	NNW	—	—	—	—
	Velocity	3.9	—	—	2.2	—	—	—	—
10 am.	Direction	NW	NNW	NNW	NNW	NNW	SW	SE	E
	Velocity	4.6	2.3	3.8	2.7	4.0	6.3	1.7	2.3

January 18th, 1911.

5 pm.	Direction	NNE	—	—	NNW	—	—	—	—
	Velocity	1.6	—	—	0.8	—	—	—	—
6 pm.	Direction	NNE	S	N	NNW	NE	NW	S	—
	Velocity	1.3	1.0	2.4	1.1	5.2	2.2	2.6	—
9 pm.	Direction	NNE	—	—	NNW	—	—	—	—
	Velocity	1.6	—	—	3.1	—	—	—	—
10 pm.	Direction	N	WNW	N	NNW	NW	—	—	WNW
	Velocity	2.2	1.8	5.6	3.2	1.8	—	—	1.3

25. *Sound area of eruption of Dec. 25th, 1910.* The sound area of this explosion (iii, §24) is quite peculiar, and differs from those of the cases already mentioned, whose detonations did not extend westwards from the mountain. As will be seen from Fig. 27 (Pl. XVIII), the explosion of Dec. 25th was practically nowhere perceived in the province of Shinano, while the sounds were distinctly heard, on the one hand, (i), in the S. part of Echigo, Kotsuke (excepting a small SW part), the NW part of Musashi, and the NE part of Kai, and on the other hand, (ii), in Hida and Etchu.* These two districts form entirely separate zones, with their length in the NS direction, respectively on the east and on the west of the province of Shinano, on whose NE

* The detonations from the Asama-yama were heard in Etchu also on the occasions of the explosions of Jan. 6th and April 3rd and 4th, 1911.

boundary the Asama-yama is situated. Outside these two zones, the sound was heard at the following four places:—

Aikawa (in Sado).....	180 km, toward the N slightly W.
Ushiji (in N. Mikawa).....	160 ,, ,, ,, SW.
Honsodo (in Shimosa)	130 ,, ,, ,, E slightly S.
Onahama (coast of Iwaki)	215 ,, ,, ,, ENE.

The wind directions at the time of the explosion were diverse, being NW or NNW in the eastern, or (1), district (Maebashi and Kumagai), and SW or WSW in the western, or (2), district (Fushiki and Takayama). Further, the direction at Nagano, Matsumoto, and Iida (in Shinano), situated between them, were respectively NNW, SE, and ENE. On the whole, however, the winds were north-westerly in Kotsuke, Musashi, and the NE part of Shinano, while they were southerly in Etchu, Hida, and the central and S. part of Shinano. It may be that the wind directions in the higher atmospheric region were on this occasion also contrary to each other, on the east and on the west of the Asama-yama.

In the following table I give the wind direction and velocity and the cloud amount on the evening of Dec. 25th, 1910.

TABLE XIV. WIND DIRECTION AND VELOCITY AND CLOUD AMOUNT, AT 6, 9, AND 10 PM, ON DEC. 25TH, 1910.

Station.	6 pm.			9 pm.			10 pm.		
	Wind.		Cloud Amount.	Wind.		Cloud Amount.	Wind.		Cloud Amount.
	Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.	
Niigata.	SE	2.3	3				SSE	3.3	2
Nagano.	NW	1.7	0				N	0.6	0
Matsumoto.	W	1.2	2				S	6.4	3
Iida.	WSW	1.7	0				—	0.4	10
Maebashi.	NNW	3.3	3				NNW	5.7	2
Kumagai.	NNW	1.2	1	WNW	3.0		NW	2.1	10
Utsunomiya.	W	1.2	1				S	6.4	2
Tokyo.	NNE	1.1	9	NW	2.4	7	NW	2.2	10

Station.	6 pm.			9 pm.			10 pm.		
	Wind.		Cloud Amount.	Wind.		Cloud Amount.	Wind.		Cloud Amount.
	Direction.	Velocity.		Direction.	Velocity.		Direction.	Velocity.	
Kofu.	NE	1.5	1				SE	1.2	0
Yokohama.	NNW	1.6	0				—	0.3	10
Yokosuka.	N	1.5	10				SW	5.3	8
Numazu.	WNW	6.2	0				SW	4.7	10
Hamamatsu.	—	0.0	10				NE	3.0	10
Fushiki.	SW	1.7	10				SW	3.0	10
Takayama.	SSE	2.7	10				—	0.0	10
Gifu.	SW	0.9	8				NNE	1.1	10
Nagoya.	ESE	1.6	10	NNW	1.4	10	N	1.5	9
Kanazawa.	S	2.7	10				SSW	2.5	10
Fukui.	SSE	1.3	10				SE	1.5	10
Hikone.	—	0.3	1				S	0.6	10
Tsu.	ESE	1.4	9				NW	1.0	1

26. Sound area of eruption of April 3rd, 1911; 1.52.30 pm.
(See Fig. 28.) The sound area of this explosion, which was in general features similar to that of Dec. 25th, 1910, consisted of two portions, as follows:—the one comprised the region about the Asama-yama, stretching 90 km E-W from Ueda to Maebashi; while the other, extending N-S for about 200 km at a radial distance of some 120 km, comprised the W. half of Etchu, the W. and S. parts of Hida, and the N. and SW parts of Mino, and the NW part of Owari, that is to say, the valley regions along the two great rivers, Imizu-gawa and Kiso-gawa (Hida-gawa), which both start at the boundary of Hida and Etchu and run respectively towards the N. and towards the S. The wind direction and velocity at the time of the explosion was as follows:—

TABLE XV. WIND DIRECTION AND VELOCITY AND CLOUD AMOUNT
AT 2 PM, APRIL 3RD, 1911.

Station.	Wind Direction and Velocity.	Cloud Amount.
Niigata.	NW 2.3 m/s	10
Nagano.	SW 2.6	10
Matsumoto.	NW 2.3	10
Iida.	N 1.4	10
Maebashi.	NNW 4.2	10
Kumagai.	NW 5.2	10
Utsunomiya.	N 0.7	10
Tokyo.	NW 4.1	10
Kofu.	W 1.4	10
Yokohama.	NNW 5.4	10
Yokosuka.	N 2.1	10
Numazu.	ENE 3.3	10
Hamamatsu.	NE 8.7	10
Fushiki.	N 4.4	10
Takayama.	— 0.2	10
Gifu.	ESE 1.5	10
Nagoya.	NW 2.9	10
Kanazawa.	NE 7.0	10
Fukui.	NNW 4.2	10
Hikone.	NNE 2.0	10
Tsu.	E 10.2	10

The wind at the time of the explosion was at Kanazawa, Tsu, and Hamamatsu, NE'yly or E'yly with velocity of 7 to 10.2 m/s. At all the other stations, however, the velocity was less than 5.4 m/s, the direction being generally NW'yly or N'yly. Especially, at the three stations of Nagano, Matsumoto, and Iida, in the pro-

vince of Shinano, and at Kofu in the province of Kai, the wind directions were respectively SW, NW, N. and E., the velocity being only 1.4 to 2.6 m/s.

I mention next two rare cases, in which the sound areas extended respectively along the Shinano-gawa valley toward the NE, and both toward the NE and the SW, from the Asama-yama.

27. Sound area of explosion on Oct. 22nd, 1911; 3.46.04 am.

The sound area (Fig. 29) is highly peculiar in form and extended from Komoro, Nagano, and Maebashi, on the SW, toward the NE mainly along the course of the Shinano-gawa, being the only case in which the detonation was heard in Niigata and the vicinity. It was about 260 km in length and included Echigo, except its N. and W. extremities; the W. half of Kotsuke; and the NE part of Shinano.

Table XVI gives the wind direction and velocity and the cloud amount at the different meteorological stations, on Oct. 22nd, at 2 and 6 am.

TABLE XVI. WIND DIRECTION AND VELOCITY, AND CLOUD AMOUNT AT THE DIFFERENT STATIONS. OCT. 22ND, 1911; AT 2 AND 6 AM.

Station.	2 am.			6 am.		
	Wind Direction.	Wind Velocity.	Cloud Amount.	Wind Direction.	Wind Velocity.	Cloud Amount.
Niigata.	E	2.6	7	E	3.3	10
Nagano.	NW	0.7	10	—	0.1	10
Maebashi.	NNW	6.7	10	NW	7.7	2
Utsunomiya.	N	6.3	4	NNW	4.2	3
Ashio.	—	0.4	10	N	0.6	10
Kumagai.	NW	4.7	10	WNW	3.5	1
Kofu.	W	0.6	10	E	1.7	10
Matsumoto.	SE	0.9	4	—	0.4	10

From Table XVI and Fig. 29, in which the wind direction at the time of the explosion (about 4 am) is assumed to be the mean of those at 2 and 6 am, it will be seen that the wind about the Asama-yama was generally north-westerly, while at Niigata it was easterly; there being no peculiar feature in the *surface* winds which could facilitate the sound propagation in the NNE direction.

28. Sound and ash-precipitation areas of strong explosion of May 31st, 1909, at 11.25 pm. (See Fig. 30.) The region, within which the ashes were precipitated, was a roughly oval zone of 55 km in length, and stretched from NE to SW, with the Asama-yama near the centre; the most south-western limit being the town of Nagakubo-Shinmachi, in Chiisagata county, Shinano. The sound area, which was nearly circular, had the maximum diameter of 80 km, the greatest radius about 55 km in length being directed toward the SW. The city of Nagano was just at the circumference of this area.

As will be seen from Table XVII, the weather in the neighbouring provinces on the evening of this explosion was quiet, the wind velocity at Nagano, Matsumoto, Iida, Takayama, and Kumagai being practically zero.

TABLE XVII. WIND DIRECTION AND VELOCITY, AND CLOUD AMOUNT, ON MAY 31ST, AT 10 PM, AND ON JUNE 1ST, AT 2 AM, 1909.

Station.	May 31st, 10 pm.			June 1st, 2 am.		
	Wind.		Cloud Amount.	Wind.		Cloud Amount.
	Direction.	Velocity.		Direction.	Velocity.	
Niigata.	NNE	2.7	10	SSE	2.3	10
Nagano.	—	0.2	10	W	0.6	10
Matsumoto.	—	0.4	10	—	0.0	10

Station.	May 31st, 10 pm.			June 1st, 2 am.		
	Wind.		Cloud Amount.	Wind.		Cloud Amount.
	Direction.	Velocity.		Direction.	Velocity.	
Iida.	NE	0.9	10	—	0.1	10
Maebashi.	N	2.8	0	NNW	3.4	9
Kumagai.	SSE	1.1	0	—	0.1	8
Kofu.	NW	3.2	8	—	0.0	5
Takayama.	SE	0.7	10	—	0.2	10
Tokyo.	S	4.1	0	S	0.9	10

29. Remarks on sound areas. The sound areas of the different eruptions considered in the preceding §§ are essentially of the following three types:—

- (A) Area diverging from the Asama-yama, as apex, toward the E. or SE.
- (B) Area consisting of two portions or zones situated respectively to the E. and to the W. of the province of Shinano, on whose north-eastern boundary the Asama-yama is situated.
- (C) Area extending from the vicinity of the mountain toward the NE.

(A) is evidently the normal type, to which belong the majority of the cases, namely, the eruptions Nos. 12, 19, 60, 20, 21, 30, and 31, the first three being specially strong outbursts. In each of these explosions, except No. 60, the extension of the sound area was more or less in the sense, but never coincided accurately with the direction, of the prevailing wind in the Kanto provinces, i.e., Sagami, Musashi, Shimosa, Kotsuke, etc. In the eruption No. 60, the winds at Maebashi, Kumagai, and Tokyo were con-

trary in direction to that of the sound propagation. In (*B*), which may be regarded as an abnormal type, and to which the eruptions Nos. 22 and 52 belong, the peculiarity is that the detonations were entirely or almost entirely not heard in the province of Shinano, and especially in the valleys of the Shinano-gawa which runs from SW toward NE through the above-named province; the sounds being, however, perceived further westwards in the valleys of the Imizu-gawa, the Hida-gawa, and the Kiso-gawa. It thus appears that the Shinano-gawa valley at distances of 40 to 60 km to the W. of the Asama-yama was in a sound shadow; the detonation becoming again audible further westwards, namely, at a distance of about 120 km. (See Figs. 27 and 28.) The *C* type, to which the eruption No. 61 belongs, occurred only once, and denotes a case of the sound propagation along the lower course of the Shinano-gawa, toward the NE. It is difficult to find out any relation between the directions of the surface winds at the different places and the extension of the sound areas for the eruptions of the *B* and *C* types. Neither does the cloud amount give any possible explanation respecting the extension of the sound areas in the special directions. All these facts point to the existence of a steady current in the higher atmospheric region, whose direction is westerly all the year round, excepting on occasions of special air disturbances.

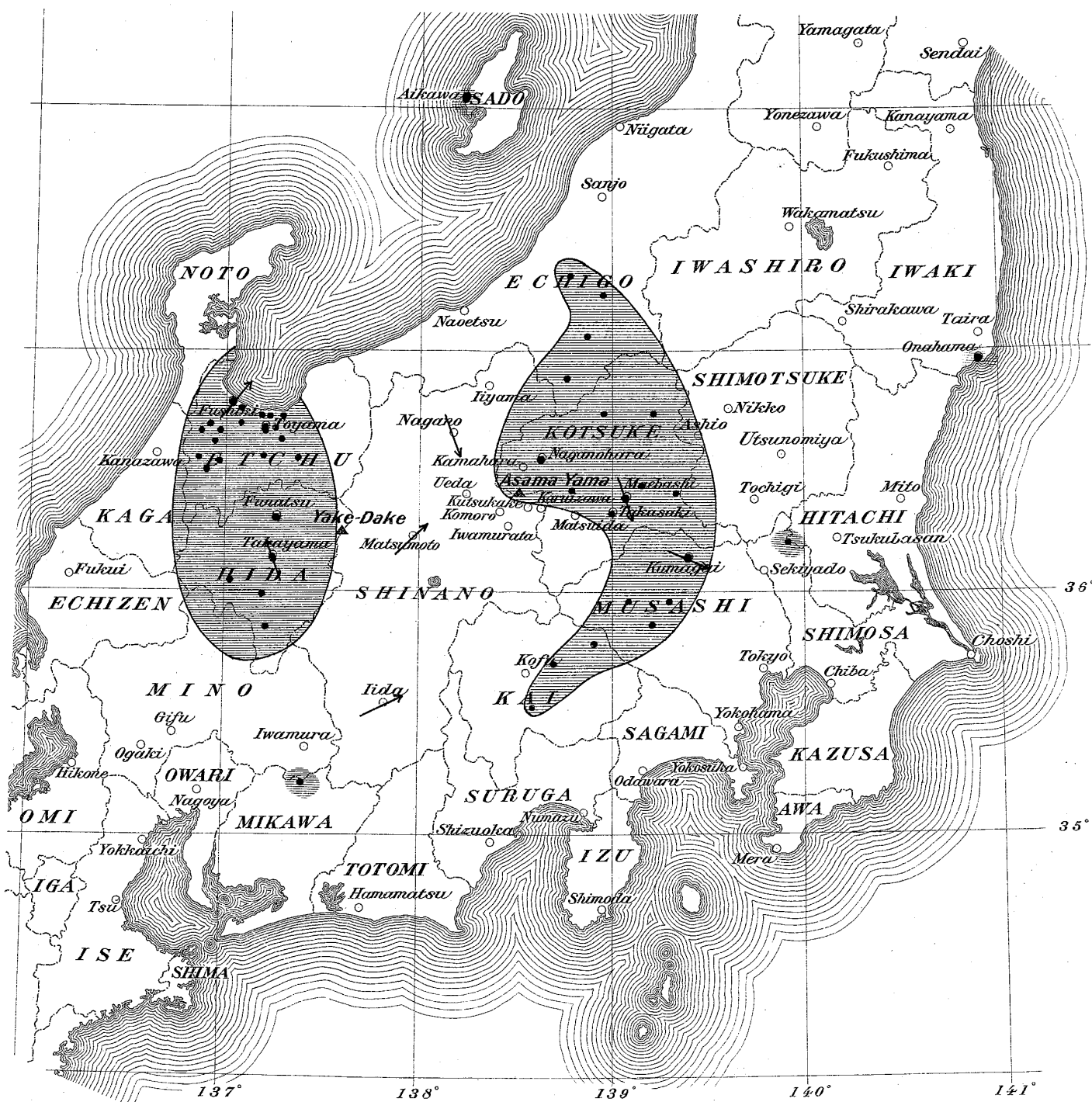
30. Direction of transportation of the ashes. The area, within which the ashes thrown out by an explosion of the Asama-yama is precipitated, is generally narrow and triangular, and diverges from the volcano, with an angle of 10° to 30° , toward Kotsuke, Shimotsuke, Hitachi, Shimosa, and Musashi; the eruption of May 31st, 1909, being the only known case in which the ashes were thrown westwards. Fig. 32 indicates the principal

Fig. 27. Sound Area of the Eruption of the Asama-yama of Dec. 25th, 1910; 8.45.30 pm.

Sound-area is shaded red.

Wind direction at the time of Eruption is shown by a red arrow.

Places where Detonation was perceived are indicated by red dots.



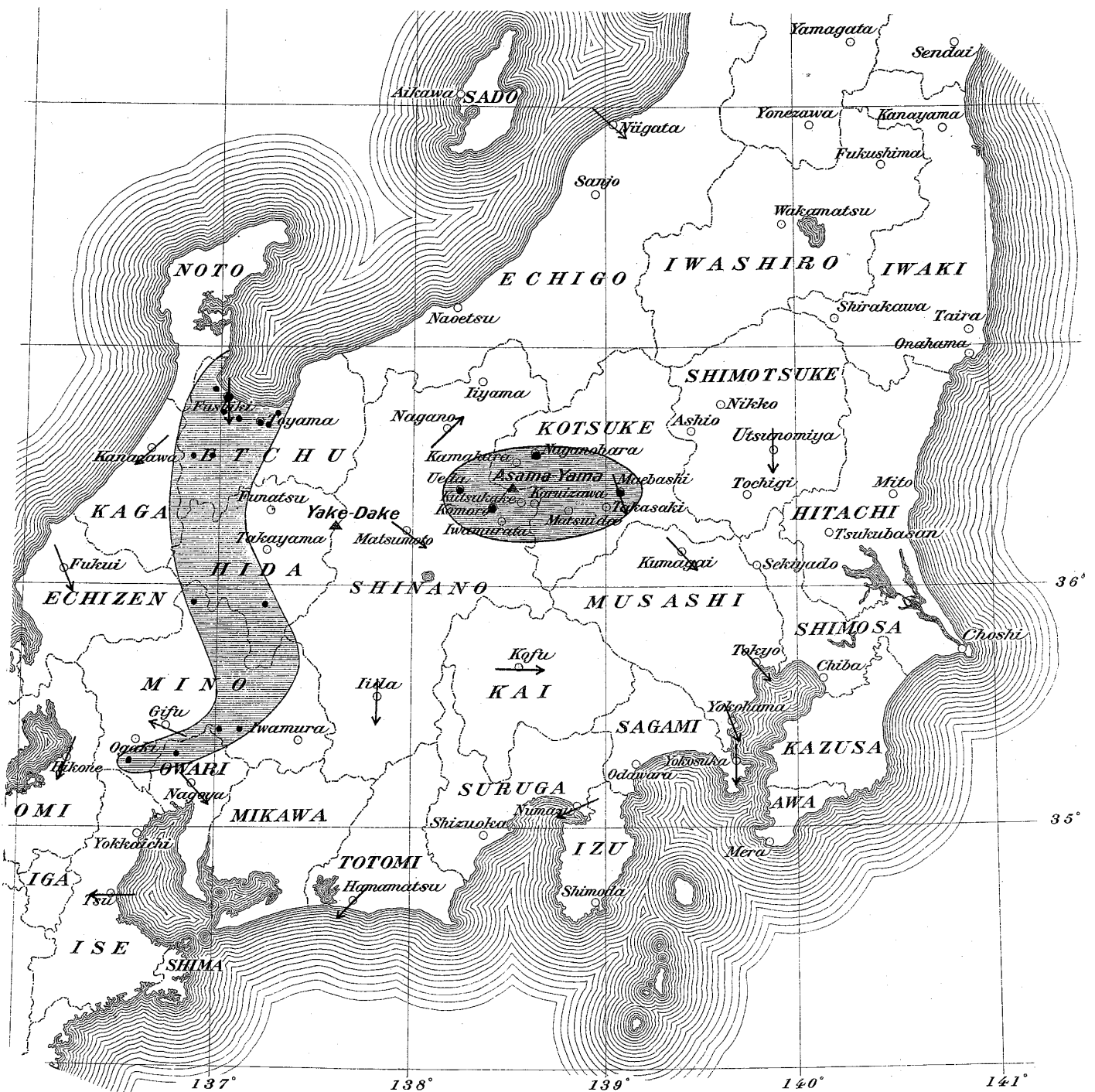
Boundary of provinces.

Fig. 28. Sound Area of the Eruption of the Asama-yama of April 3rd, 1911; 1.52.30 pm.

Sound-area is shaded red.

Wind direction at the time of Eruption is shown by a red arrow.

Places where Detonation was perceived are indicated by red dots.



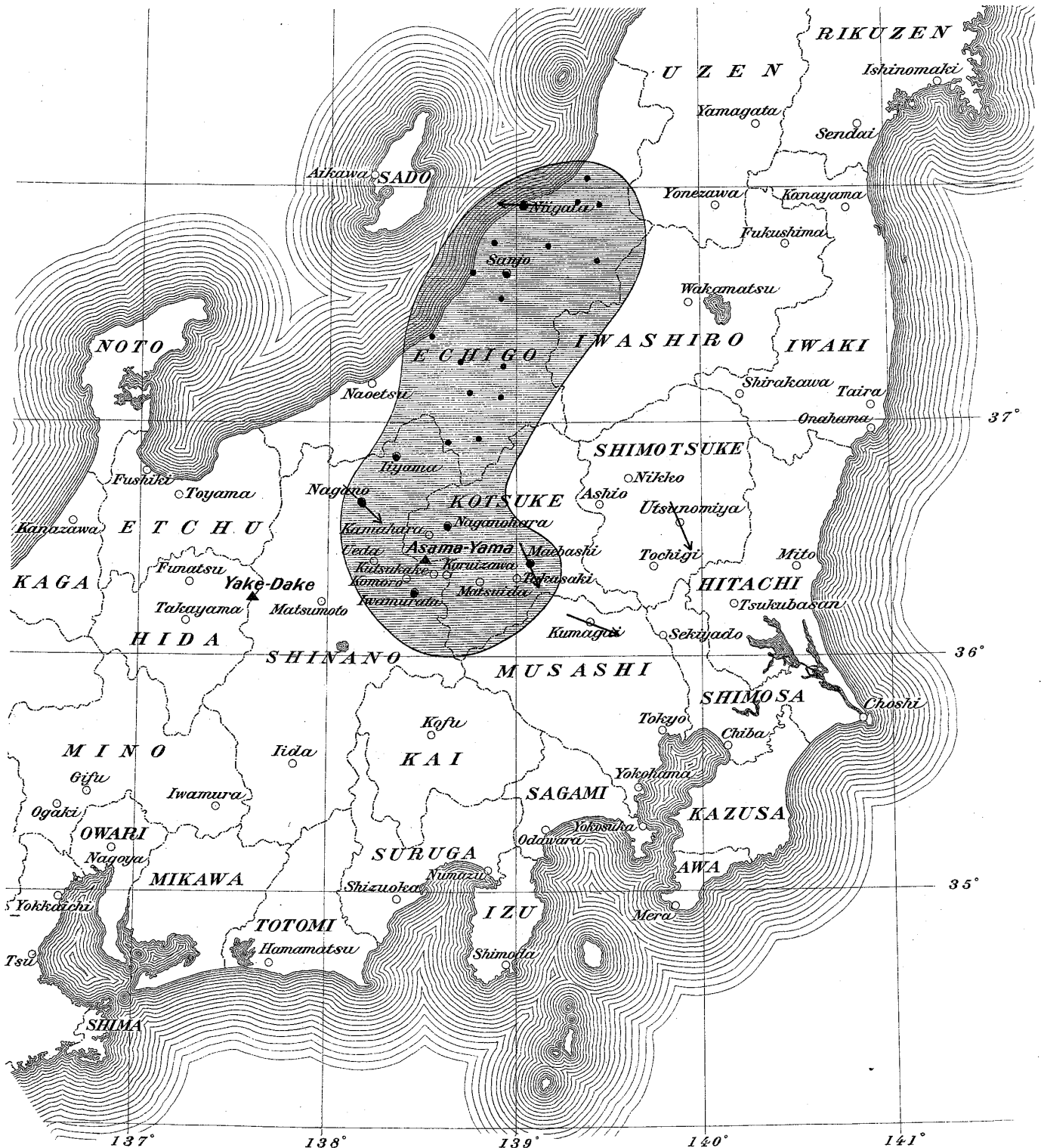
Boundary of provinces.

Fig. 29. Sound Area of the Eruption of the Asama-yama of Oct. 22nd, 1911; 3.46.04 am.

Sound-area is shaded red.

Wind direction at the time of Eruption is shown by a red arrow.

Places where Detonation was perceived are indicated by red dots.



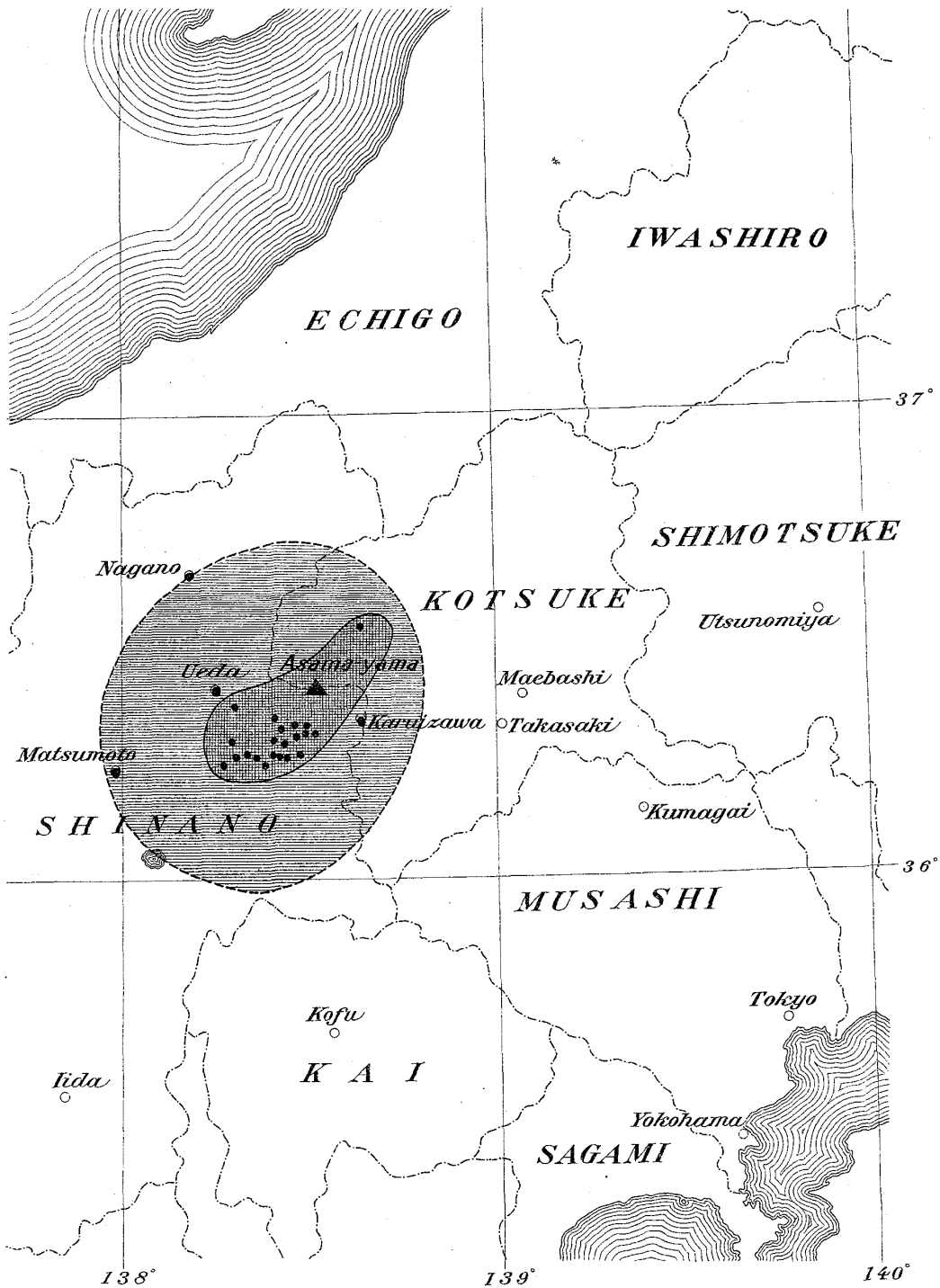
Boundary of provinces.

Fig. 30. Sound and Ash-precipitation Areas of the Asama-yama Eruption of May 31st, 1909; 11.25 pm.

Sound-area is shaded *red* (thin).

Ash-area " " " (deep).

Places where Detonation was perceived are indicated by *red dots*.



Boundary of provinces.

Fig. 32. Map showing the Principal Direction, or Axis, of the Ash-precipitation Area in the different Eruptions of the Asama-yama.

- (1)....1783.
- (2)....Jan. 22nd, 1900.
- (3)....Feb. 7th, " "
- (4)....Feb. 14th, " "
- (5)....Feb. 15th, 1900.
- (6)....Dec. 7th, 1909.
- (7)....Dec. 2nd, 1910.
- (8)....May 8th, 1911.

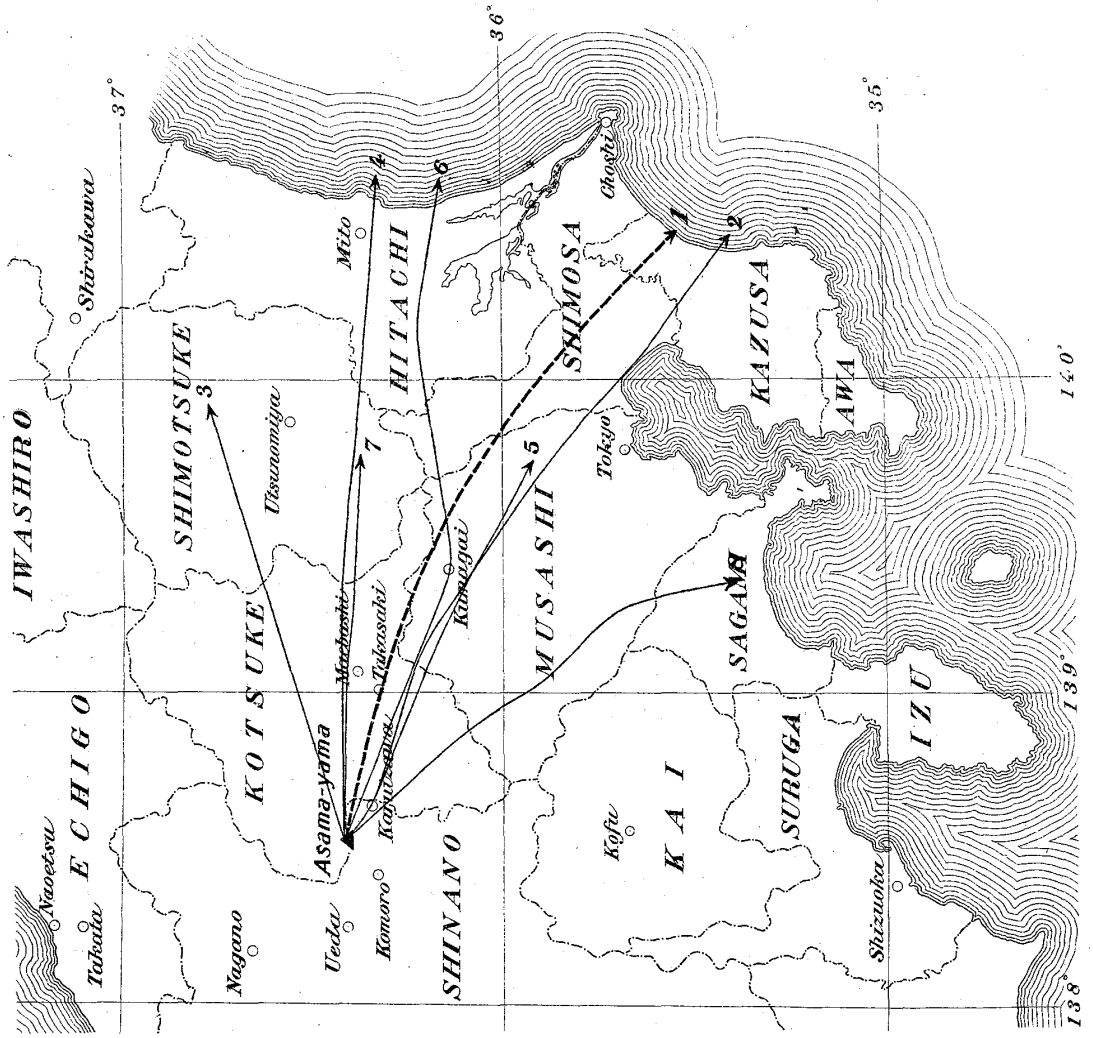
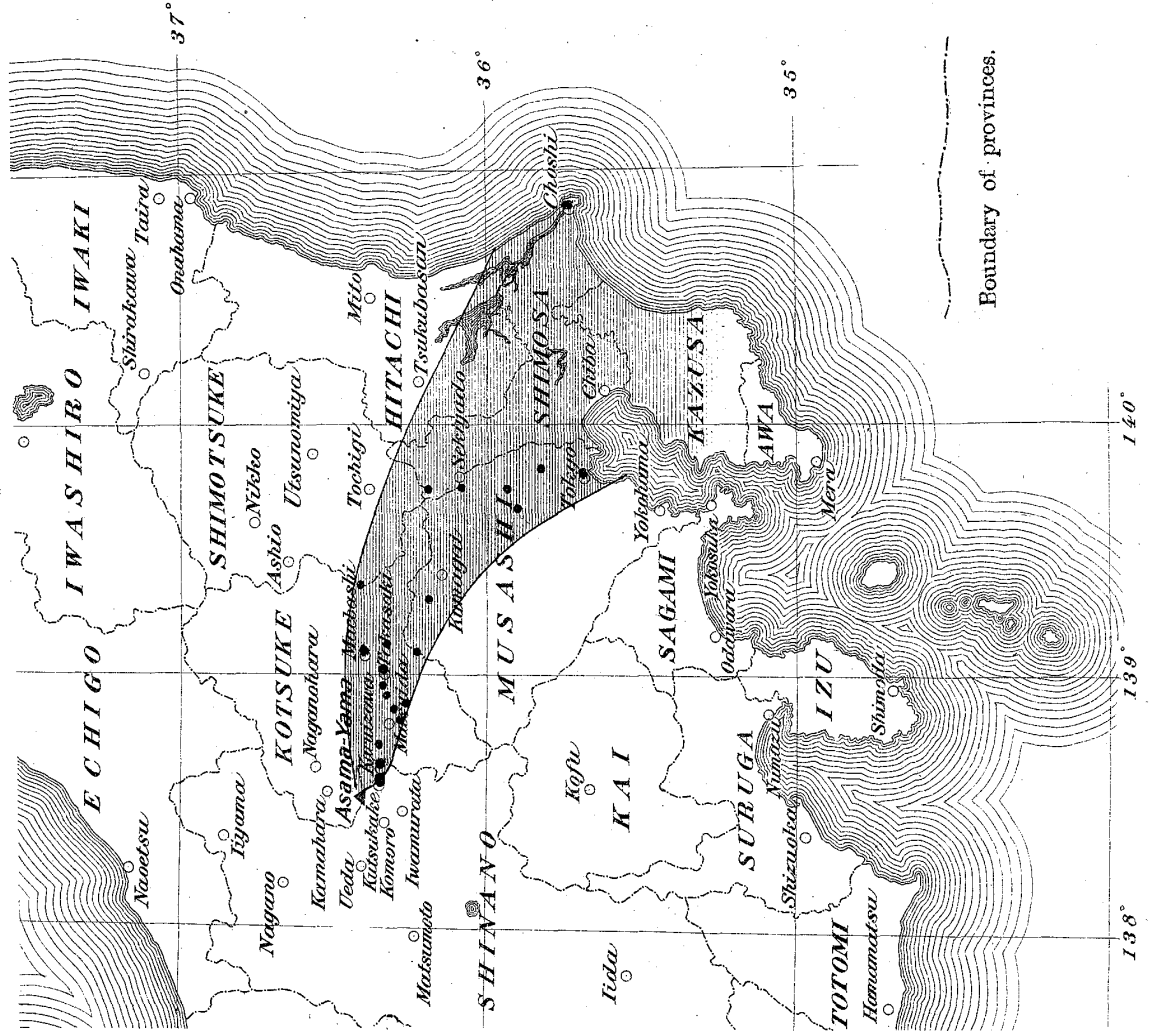


Fig. 31. Ash-precipitation Area of the great Eruption of the Asama-yama in 1783.

Red dots indicate the places where the amount of precipitation of ashes was greater than 1 inch.



directions or the axial lines of the ash-precipitation areas of the following eight eruptions :—

- (i) Aug. 1783 (The Temmei disaster).
- (ii) Jan. 22nd, 1900.
- (iii) Feb. 7th, „
- (iv) „ 14th, „
- (v) „ 19th, „
- (vi) Dec. 7th, 1909.
- (vii) Dec. 2nd, 1910.
- (viii) May 8th, 1911.

According to Fig. 32, the directions toward which the ashes were carried varied from ENE to ESE, being mostly towards the ESE. It must hereby be noted that the eruptions (ii) to (vii) occurred in the winter months of December, January, or February, but the final and most violent phase of the great eruption of 1783 occurred in the summer epoch of the end of July and the beginning of August, when the surface wind must have been southerly. Thus it seems that the prevailing wind in the higher atmospheric region over the central Japan seems in the normal state always to be WNW or W.

The velocity with which the ashes were carried away from the Asama-yama varied from 17 to 35 m/s, as follows :—

Dec. 7th, 1909.....	22 metres per sec.
Jan. 3rd, 1911.....	17 „ „
„ 6th, „	35 „ „

CHAPTER V. REPETITION OF THE SOUNDS AND THE ZONE OF SILENCE.

31. Observations on detonations. As stated in Chapter VI, the detonation on the occasion of the explosion of Dec. 2nd, 1910, which was distinctly perceived in Tokyo, consisted of three dif-