

14. *On Sound Phenomena of the Idu Earthquake of Nov. 26th, 1930.*

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1. On Mt. Tukuba which lies in the north-eastern part of the Kwantō district, some characteristic earth-sound is heard accompanying about a half number of sensible earthquakes. Sometimes, we notice some such noises even on the occasion of insensible earthquakes.

They generally begin almost simultaneously with the arrival of the primary phase of each earthquake. They continue during its principal portion with fluctuating intensities and subside gradually in their intensities. The duration of these sounds ranges generally from 10 to 15 seconds and occasionally amounts to as long as 30 seconds.

A destructive earthquake occurred at 4h 03 m on Nov. 26th in Idu Peninsula. On the early morning of this very day we experienced characteristic sounds at several minutes after the beginning of the moderately intense earth trembling.

According to the report on this earthquake of the Central Meteorological Observatory, sounds were heard in the epicentral area and in two zonal areas far from it, the one lying from 120 kms. to 170 kms. to the north-east, the other between 160 kms. and 300 kms. to the west of the origin.

In order to obtain some informations regarding the geographical distribution of the limit of audibility, we send letters to the headmasters of the primary schools in the neighbouring districts asking to inform us about the nature of the sounds and the time when they were heard. The reports received from them were 102 in number, and this number may not be sufficient for getting a full information regarding the distribution of the places where the sounds were heard, but we may be allowed to discuss a little about the nature of them from these data.

In Fig. 1, the cross represents the place where no sound was perceived, the circle represents the place where the sounds were noticed which did not differ from those heard on the occasion of the ordinary near earthquakes, and the double concentric circles represent the place

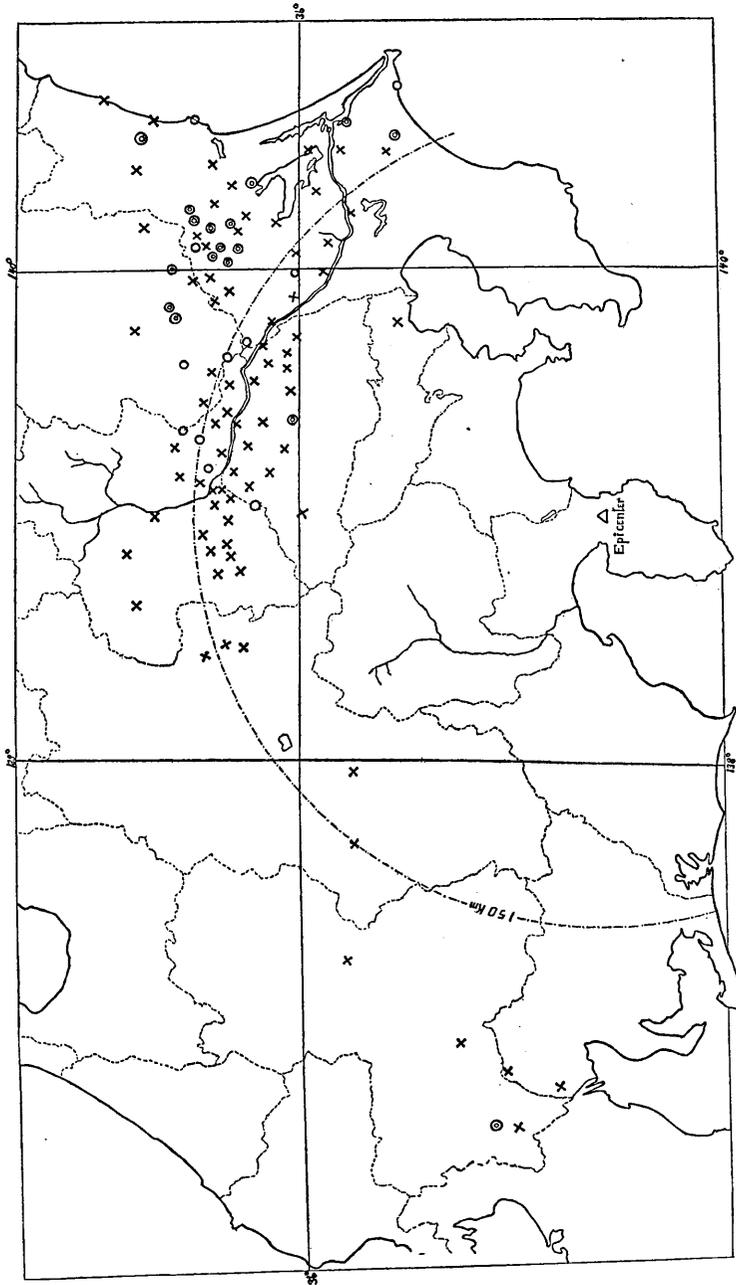


Fig. 1.

where the peculiar rumbling noises were perceived after the beginning of the earthquake. The sounds were somewhat like those of distant thunders, continuous discharges of a gun, fall of heavy blocks of rock, or the eruption of Asamayama.

At some places among the last mentioned places, not only the detonating noises as above stated, but also the ordinary earth-sounds were heard at the beginning of the earthquake.

2. Our personal experiences at Mt. Tukuba were as follows.

At the beginning of the earthquake the sliding-doors rattled fairly long and then slow vibration of the house was felt, indicating the arrival of the principal portion of the earthquake. After a while the earth vibration ceased, and after about five minutes had passed it was renewed making the house to rattle, when we heard three intense and two feeble sounds like those of the fall of heavy stones.

The seismometer at our station got out of scale at the early part of the earthquake, but recorded its later part. By this record we see the earth vibration somewhat subsided about six minutes after, and then it revived in its intensity about ten minutes after the time of the occurrence. We may notice that, our bodily experiences coincide fairly well with the result obtained by the seismometer.

Thus it seems that the sounds arrived here about ten minutes after the beginning of the earth shocks.

At two towns at the foot of the mountain, namely Kakioka and Tanikai, they had the same sensation as what was experienced at our station. At Kakioka strong shocks began at 4 o'clock in the morning and continued for about five minutes, and then at 10 minutes past 4 o'clock the earth vibration was renewed, when three sounds were noticed like those of cannonading. Moreover, at Akasaka, Gifu Prefecture, situated at about 235 kms. to the west of the origin of the earthquake, a few noises were noticed several minutes after the arrival of the earthquake waves.

3. By the anomalous geographical distribution of the places where the sounds were perceived on the one hand, and the time when they noticed at these places on the other, we came to a conclusion that they were propagated from the epicentral area through the upper atmosphere. As the velocity of the sound waves range from 240 m to 310 m per second in the case of an anomalous propagation as is already known,¹⁾ they should have arrived at Tukuba, which is about 160 kms. distant from

1) Wien-Harms, Handbuch der Experimentalphysik, XXV, Teil 3.

the earthquake origin, at 8m 36s to 11m 6s after they had started, and this was actually the case.

Although the sound waves may be generated in the atmosphere by the refraction of the earthquake waves of high frequency particularly as in the case now in question where the hypocentre had been laid shallow under the hard andesite rock in the volcanic area, owing to the lesser dissipation of energy of the earthquake waves, it may rather be plausible to attribute the source of the sound waves which were intense enough to be propagated to so distant places, to the landslips which had occurred at many places in the epicentral area either during or perhaps shortly after the destructive earth concussion.

In Fig. 2 is shown the weather chart at 6 a.m. of Nov. 26th, publi-

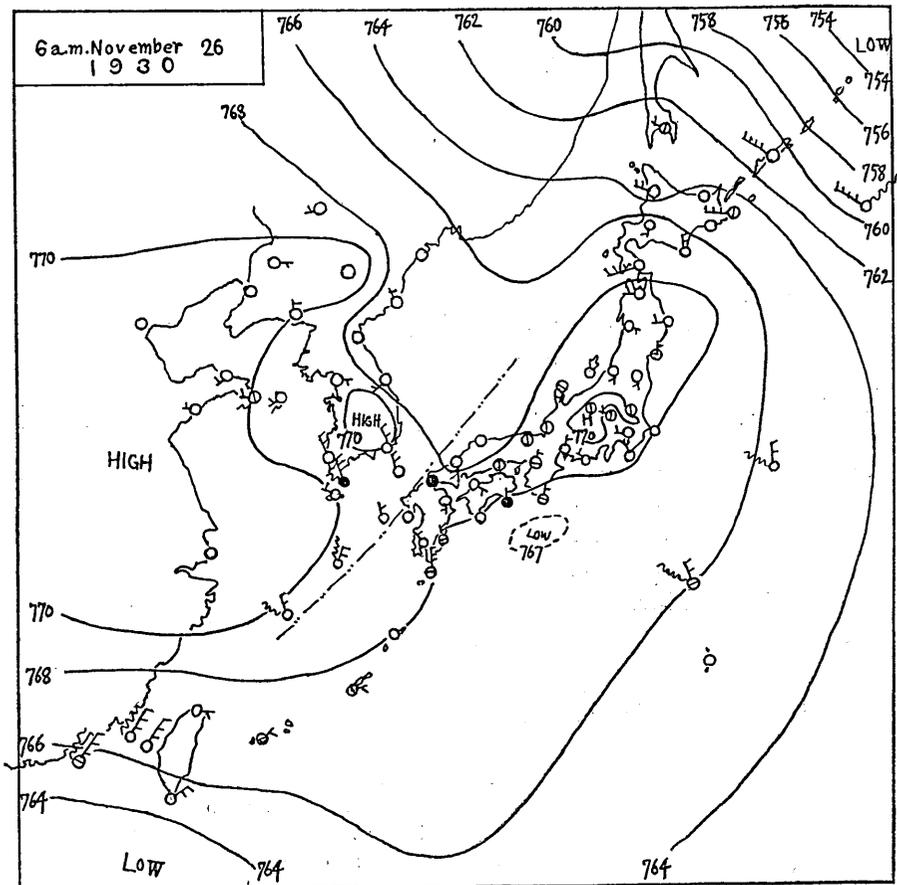


Fig. 2.

shed by the Central Meteorological Observatory. As is to be seen from the figure, the weather at that time was of the normal winter type, and calm under a detached high over the central Japan.

According to Fujiwhara's² classical study on the abnormal propagation of sound waves in the atmosphere, the region of audibility is generally continuous in winter and no detached region appears except when a powerful cyclone exists in the vicinity of the sound source, so that our case may be regarded as an exceptional one.

In Fig. 3 and 4 the temperature of the free atmosphere and the velocity of wind at the Tateno Observatory are shown respectively.³⁾

4. As we have no information about the sound phenomena in the Pacific ocean at the south of the source, we cannot decide whether the anomalous propagation had been caused mainly by the distribution of temperature in the upper atmosphere, or by the monsoon wind as had been fully discussed by Professor S. Fujiwhara.⁴⁾

At any rate, it seems that the condition was favourable for the formation of a detached area

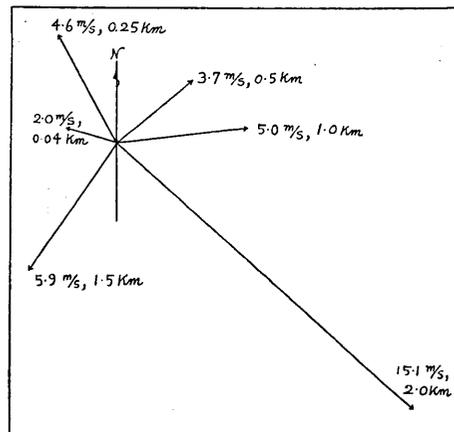


Fig. 3.

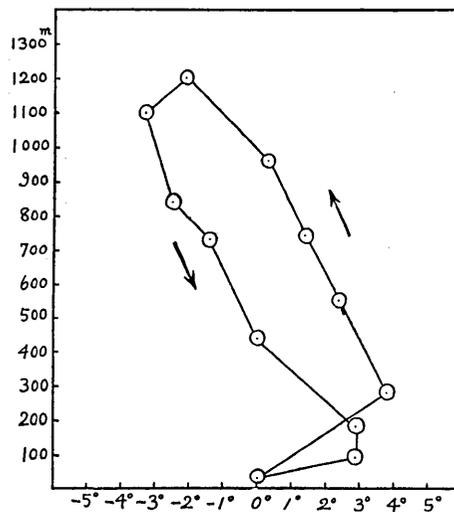


Fig. 4.

2) S. FUJIWHARA, *Bull. Cent. Met. Obs., Japan*, 2 (1916), 39.

3) As is to be seen from Fig. 4 there was a inversion of the atmospheric temperature which may have been caused by the night cooling. We confirmed by simple calculation that the sound waves have not been transmitted to so distant places by this inversion of temperature.

4) S. FUJIWHARA, *Bull. Cent. Met. Obs., Japan*, 2 (1912) & 2 (1916).

of audibility to the northern side of the source, as at Tateno Observatory up to 1 km. from the ground the northern wind, and above it the southern wind respectively had been blowing and the velocity of the wind had been increasing with the increasing height.

In conclusion, the authors wish to express their most cordial thanks to Professors Torahiko Terada and Chûji Tsuboi for their valuable advices and discussions which they have kindly given, and to the Director of the Tateno Observatory for his kindness in informing us the whether condition there.

Appendix.

Table I. The temperature of the free atmosphere
at 7^h on Nov. 26th, 1930 observed
at Tateno Observatory.

time	height in meter	temperature
7 ^h 12 ^m	26	0.0°C
18	282	3.8
19	548	2.4
20	743	1.4
21	961	0.3
23	1205	- 2.1
23	1097	- 3.3
24	844	- 2.5
25	726	- 1.4
29	444	1.0
31	180	2.9
33	94	2.9
37	26	0.0

Table II. The velocity of wind at 7^h on Nov. 26th,
1930 observed at Tateno Observatory.

height	direction	speed
0.04 km	285°C	2.0 m/s
0.25	331	4.6
0.5	51	3.7
1.0	174	5.0
1.5	214	5.9
2.0	132	15.1

Table III. List of places where the sounds were heard.

In Ibaraki prefecture.

Tukuba: Above stated.

Kakioka: Ditto.

Tanikai: I was staying for the night in my school. I was frightened to get up with a start by the severe shocks, and went into the office-room to examine the remaining fire in a brazier.

When I was going to get out of door, the shakings had been fairly subsided, and I went to bed. After several minutes had passed, the shakings was renewed, and sliding doors were forced to open by and by making rattling noises, and I was obliged to get up again to shut them. At that time, according to my vague memory, I heard feeble sounds accompanied by vertical shakings of the floor.

Makabe: Although the time was uncertain, I heard several detonating noises like those of cannonading or an eruption of a volcano.

A few of my colleagues also heard the similar noises. The noises were quite different from the ordinary earthquake sound.

Inada: Immediately after the earthquake, I heard a few detonating noises. I supposed that they may have been caused by an eruption of a volcano.

Ogawa: After the beginning of the earthquake, I heard several sounds.

Oo: I noticed a few noises.

Oota: Before and during the earthquake I heard a few detonating noises, which made the doors, especially sliding-doors, to rattle.

Koise: Shortly after the beginning of the earthquake I heard noises which seemed to come from beneath the ground. Some men who are living in the neighbouring district had the same experience.

Kasama: 1. Before the beginning of the earthquake I heard distant noises.

2. It shaked mostly in NS direction during about one minute. The pendulum clock was stopped. The bodies on shelves fell down.

3. After the shaking had ceased, I heard a few detonating noises like those of an eruption of Asamayama.

4. Afterwards, after-shocks were felt.

Hiraiso: According to the experiences of two teachers of our school,

the feeble shocks were felt after they heard noises in the early morning on Nov. 26th.

Koga: The earthquake occurred at the same time when I heard noises in the early morning on Nov. 26th.

Iwase: Here the noises were noticed at the beginning of the earthquake.

Mizukaido: Only a single sound was heard before the earth shaking became strong. After 10 seconds had passed, the earthquake began to shake violently in EW direction.

In Tiba prefecture.

Yökaitiba: Here many people heard several sounds after the earthquake.

Omikawa: I heard noises during several minutes like those caused by strong wind. Supposing that the wind has been getting up, I got up and opened the door.

Iioka: Some of the teachers of our school heard noises like those caused by a revolving propeller of an aircraft at the NE. Others did not notice them.

In Totigi prefecture.

Maoka: Shortly after the occurrence of the earthquake, some men heard continuous explosive noises at the south. The noises likened to those of the cannonading at some distant place, the distant thunders, or the continuous explosions of a volcano.

Mibu: Some men heard noises like those of cannonading immediately after the earth trembling has ceased.

Isibasi: They say that they heard noises as caused by a coming train just before the occurrence of the earthquake, and they heard a few explosive noises at the early part of the earthquake. Two after-shocks were felt, the first one was slightly stronger than the second.

Kuzuu: Here the noises were heard fairly intensely before the arrival of the earthquake waves.

Hudioka: Here we heard uncommonly long and intense earth-sounds. We talked with one another that a destructive earthquake must have occurred somewhere. No casualties occurred to men and beasts.

In Gumma prefecture.

Kiryû: The earthquake occurred at 3 h 57 m on Nov. 26th accompanied by earth-sounds. The earth vibration was not severe and continued for about two and half minutes.

Oniisi: An earthquake occurred after a noise was heard like the detonation caused by the eruption of Asamayama.

Yabutukamoto: All of seventeen teachers of our school heard noises like those with the ordinary earthquake.

Isezaki: A slight earthquake continued for one minute and thirty seven seconds. A single earth-sound was heard before the occurrence of the earthquake and continued for about ten seconds.

In Saitama prefecture.

Matuyama: Here earth-sounds were heard after the earthquake.

In Gifu prefecture.

Akasaka: At Akasaka a few noises were noticed at several minutes after the arrival of the earthquake waves.

14. 昭和五年十一月二十六日伊豆地震に伴つた
音響異常傳播に就いて

地震研究所 { 井 上 宇 胤
 { 杉 山 友 紀

地震研究所筑波山支所に於て十一月二十六日午前四時三分の伊豆大地震の發震後約十分程して數回音を聞いた。主に關東地方の小學校長あてに手紙を出して此の音に關する報告を貰つた。それによつて筑波に於ける音と同様な音を聞いた場所が可成りあつた事を知つた。それ等の場所の分布及び音を聞いた時間からして、此の音は普通近地震に伴ふ地鳴とは異なり震源地附近の音元から大氣の上層を傳つて來たものと思ふ。尙此の音は地震波によつて直接に起されたものとするよりも、震源地附近に非常に澤山に起つた山崩によるものと思ふ。