2. *Recent Seismic Activities in the Idu Peninsula. (Part 1.)*

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Introduction.

For the benefit of those who may be reading on the subject of the Idu peninsula earthquake for the first time, it should be explained that early last year, 1930, some 9 months before the occurrence of the destructive Idu earthquake which forms the subject of this paper, the town of Itô and vicinity, in the Idu peninsula, with one short period of intermission was, figuratively speaking, bombarded daily for more than two months by showers of earthquakes, the number of sensible ones of which at the end reached the total of more than 4880 shocks. Beginning in February 13, 1930, they increased progressively in both intensity and frequency until the culmination came as the big shock of March 22, at 17h 51m; after which they gradually declined in severity and in numbers, but on May 7 renewed their activities. In August however things had quieted down.

To the amazement of all in the town of Itô, the swarm of earthquake shocks began on November 7, and as on the previous occasion, daily increased in number and severity. On November 25 as many as 690 shocks were recorded at Itô, and on the morning of the 26 came the main destructive shock. It is of interest to note the enormous number of fore-shocks that preceded the principal earthquake.

The purpose of this paper is to consider the relationship that appears to hold between the earthquake swarms that preceded the Itô earthquake of March 22 and the swarms that acted as the prelude to the destructive earthquake of November 26. It will therefore be fitting to begin with a study of the Itô earthquake.

Observations on the Itô Earthquake.

With the object of studying these earthquakes on the spot, a party consisting of members of the Earthquake Research Institute and of the

Seismological Institute of the Tokyo Imperial University had established a network of five temporary seismic stations in and around the disturbed area, and the work of observation started from March 6. Seeing that the main shock–the most important one for our observation occurred sixteen days later, we were not belated as was at first feared. The main object of the seismic survey was to ascertain the foci of these innumerable shocks and their depths.

Unusual Focal Distribution of the Itô Earthquakes. The net results of observations obtained from these five stations are shown in Fig. 1. It will be seen that the foci cluster themselves within a small area in contrast to the after-shocks of the Tango earthquake, which were spread

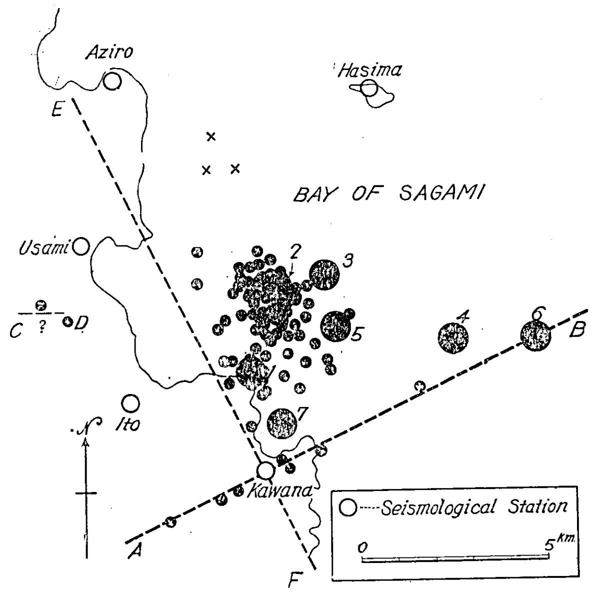


Fig. 1. Distribution of the epicentres of the Itô earthquakes.
Large dots indicate conspicuous earthquakes.
1 : Mar. 22. 2 : May 9. 3 : May 12. 4 : May 14
5 : May 17. 6 : May 26. 7 : June 26.
Small dots; in March. Crosses; in April.

over a comparatively large one. The area embraced by the former could be circumscribed within a circle of radius only 2 kms., whereas in the latter, they embraced a zone roughly 50 kms. long and 15 kms. wide.

It is of interest to see that besides the foci clustered under Itô Bay, there are some on the line passing near Kawana, extending in an almost N.E. - S.W. direction. A similar line (CD) passing near Usami runs in a east-westerly direction. It will be understood that the foci distributed on these two imaginary lines are nothing more than projections on the surface ground of the foci of earthquakes that have originated along a vertical fault plane. The existence of these planes having been deduced seismometrically, for their geologic significance we must await the verdict of the geologists; but that they are boundaries of crustal blocks there seems hardly room for doubt.

Three-dimensional focal distribution. The method of ascertaining the foci by stereometric projection was first applied to the investigation of the after-shocks of the Tango earthquake. Under Prof. Imamura's direction the same method was employed on this occasion. Briefly stated, it is an investigation of the distribution of the depths of the seismic origins–most important in the study of focal distribution but very difficult of realization.

Let us suppose that a number of shocks have originated along a fault plane that extends to the surface ground and shows itself there as a fault line. Let us suppose also a vertical plane normal to this fault line, which we shall call the projection plane. If now we project on this hypothetical plane the foci of the shocks just mentioned and join the points thus projected, they should form a straight line. Next let us suppose another vertical projection plane, not normal to the surface fault line as in the preceding example, but parallel with the fault line. The foci projected on this second projection plane as a number of points, instead of forming a straight line, will now be scattered without any semblance of order. It is obvious that when the projected epicentres form a straight line, the foci might have originated in a straight line just as well as along a vertical plane.

In the case of the former, obviously no matter in what angle we may project them the projected points will lie on a straight line. In a special case they may project to a single point.

Upon using the foregoing method we generally find that the projected points assume certain orderly forms, while the selection of the proper projection plane is always attended with more or less difficulty; although, if the depths of several shocks are already known, the choice is rendered much less difficult.

In studying the focal distribution of the present earthquake clusters we shall select the principal ones and apply the two methods of stereometrical projection. The first is shown by line EF in Fig. 1 and the second by line AB. These two are hypothetical surface fault lines as previously explained. The distribution of the foci are obtained by projecti n as follows:

(1). In Fig. 2, the distribution of focal depths as projected on plane EF is viewd from the east. An examination of the figure shows that with the exception of the foci projected on lines AB and CD, practically all the foci are clustered in the form of an inverted cone,

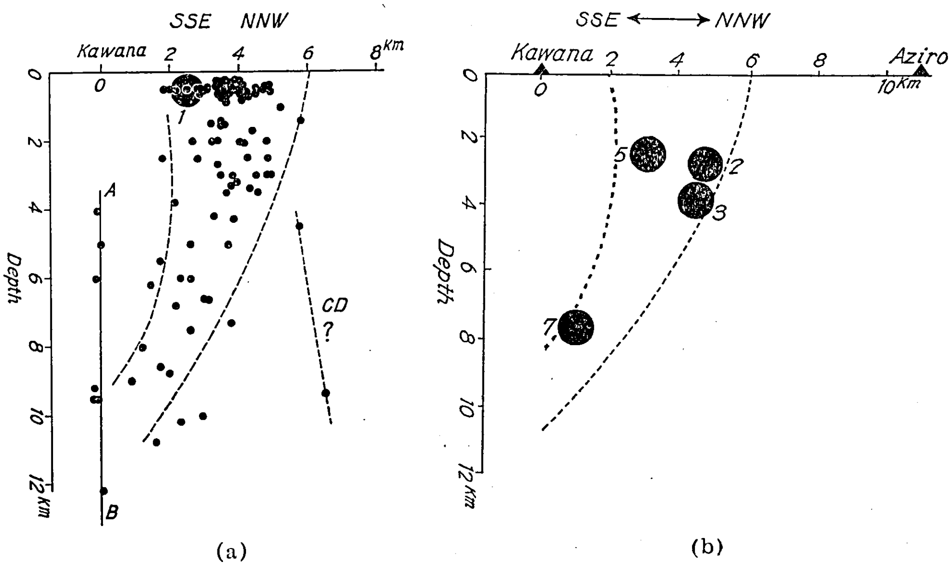
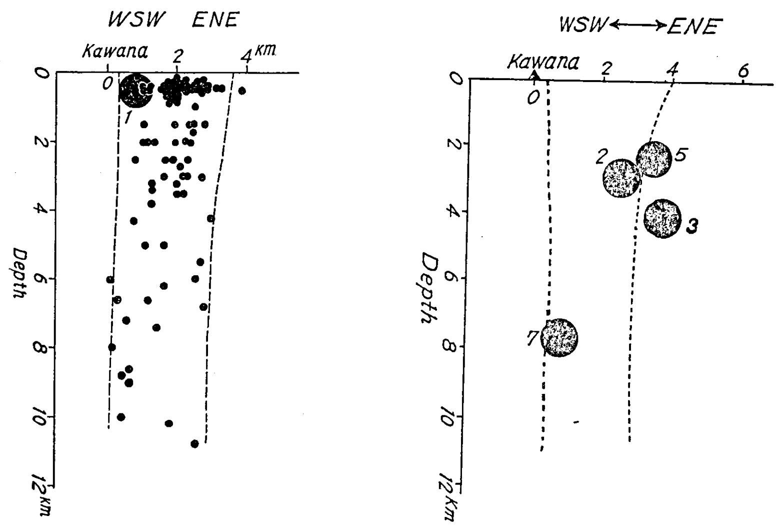


Fig. 2. Seismic foci of the Itô earthquakes projected on a vertical plane, the surface trace of which is indicated by EF-line in Fig. 1.
(a) relates to the earthquakes of March.
(b) relates to those of May and June. Origins No. 4 and No. 6 in Fig. 1 are omitted here.

densely packed at the top and gradually thinning downwards. The Projected foci as represented by line AB suggest that all the earthquakes there originated along a plane. We further see that they originated from depths greater than 4 kms. It should be added that this so-called hypothetical plane AB was found by a series of precise levellings to be a line of discontinuity between two contiguous crustal blocks. As to line CD there are not enough origins on it to justify any conclusions.

(2). Fig. 3 (a) shows the same projection as treated in the preceding paragraph, but viewed from the south. Here the foci are seen grouped together in a more orderly manner, but also densely toward the surface and gradually thinning downwards and ending at a depth of 10 kms.



(a) (b)

Fig. 3. Seismic foci of the Itô earthquakes projected on a vertical plane, the surface trace of which is designated as AB of Fig. 1.
(a) relates to the earthquakes of March.
(b) relates to those of May and June. Origins No. 4 and No. 6 are omitted here.

In both these two figures the projections represented by lines AB and CD have been omitted. From these two projections we are led to conclude from the distribution of the majority of the earthquake shocks which harassed Itô and vicinity for nearly two months, that they emanated from a region having the shape of an inverted cone, in structure weaker than the surrounding rock mass. This sets one wondering whether it might not be the *neck* or *vent* leading to an extinct and buried volcanic crater.

The foregoing covers only observations up to the end of March. There was recrudescence of activity in May, when as shown by the method of projection, the foci of the shock-swarm had burst out, so to say, from the eastern side of the 'neck' thus enlarging the neck on that side without however causing any further deformation. Two shocks of importance then followed on June 26, the foci of which were in the neck as seen in Fig. 2(b) and 3(b). Excepting the earthquakes that occurred in the neighbourhood of Mt. Oomuro, there were no more serious disturbances until Nov. 7.

Here a few remarks might be made on the AB line of Fig. 1, the north-eastern end of which touches the 80 m. depression that occurred on the bottom of Sagami Bay at the time of the great 1923 Kwantô earthquake. By producing the line still further it cuts at right angles two great faults in the same sea floor. By producing it still further again it will reach the great trough (100–180 m.) that formed on the same sea floor at the time of the earthquake just mentioned. The centre of this great trough lies some 20 kms. north-east of Kawana, one of our seismic stations.

After careful study of observations as made at Tokyo of the great Kwantô earthquake of 1923, Professor Imamura came to the conclusion that the shocks originated from more than one source, and that they were in weak zones running N.W.- S.E. in the sea floor of Sagami Bay and vicinity. The existence of three different sources of seismic origin was detected through certain characteristics that were

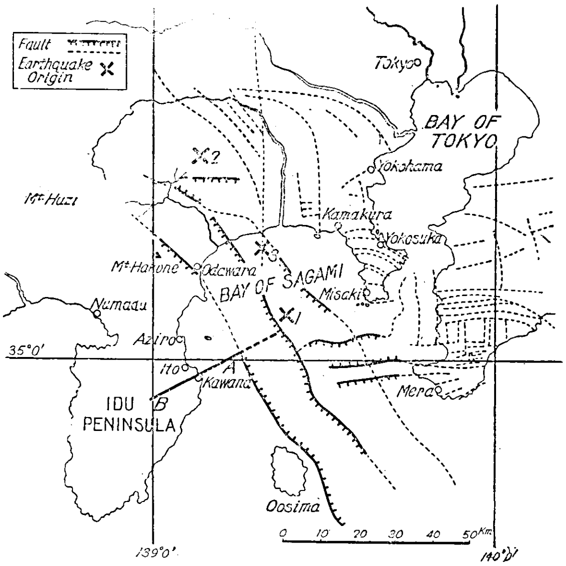


Fig. 4. Shows the system of faults in and around the Bay of Sagami and the origins of the great Kwantô earthquake of 1923.

exhibited in the seismograms within 10 seconds from the beginning of the earthquakes. The origin first in point of time was in the middle part of Sagami Bay, 75 kms. 35°W. of Tokyo, and indicated by X_1 in Fig.4. The second big shock originated in Mt. Tanzawa (X_2), 72 kms. S. 60°W. of Tokyo, the seismic waves from which reached Tokyo 3 sec. after the arrival of that from the first origin. The third shock originated in Sagami Bay off the coast of Odawara, 67 Kms. S.W. of Tokyo. The seismic waves from this origin reached Tokyo 4½ sec. later than the one last mentioned. As for the other origins, the waves from them were masked to such an extent by the three waves just mentioned that it was impossible to isolate them.

Now the line of weakness AB that appeared with the Itô earthquake, when produced intersects at right angles the line of weakness in Sagami Bay, whence originated the first shock of the great Kwantô earthquake; but it is important to bear in mind that when the latter line was active in 1923, the former (AB) line was inactive or dormant, as was proved by subsequent precise levellings. Now it need hardly be remarked that where lines of weakness in the earth's crust intersect in the manner just stated, it forms a zone of tectonic weakness, thus forming a good vent for the release of pent-up volcanic forces, to say nothing of seismic forces. By assuming the correctness of the magmatic intrusion theory of Professors Ogawa and Ishimoto as the primary cause of earthquakes, there is no difficulty, considering the proximity of notorious volcanic zones, in concluding that the great Kwantô earthquake of 1923 was due to effects of intrusion of magma first into the weak intersections of fault running N.W.–S.E. and line AB.

The Destructive Idu Earthquake of Nov. 26, 1930.

This earthquake occurred Nov. 26 at 4h. 3m. From observations made at Tokyo, Prof. Imamura concluded that, like the great Kwantô earthquake of 1923, this earthquake had a multiple source of origin; namely, four different origins distributed over the northern part of Idu Peninsula, about which destruction was very great. The first origin developed near the town of Ukihashi, 10 kms. N.W. of Itô. The other three sources are situated W. or S.W. of it. Damage caused by seismic waves sent out from the first origin was slight compared with those from the remaining three sources, which were destructive. The foreshocks that kept up for 20 days prior to the main shock of Nov. 26 all came from one (1st) origin, and their number reached the total of 3411 instrumental shocks.

As observed at Itô, the initial motion of these fore-shocks without exception had a N.W. direction, the duration of the preliminary tremors being 1.5 to 2 sec. At Aziro they were E.N.E. and about 1 sec. respectively, while Mr. Kunitomi at Mishima station obtained a direction downward of S.S.E. and 2.5 sec. for the duration of the mean initial motion. From these data the fore-shocks were deduced to have originated near Ukihashi, lying 10 kms. N.W. of Itô. A remarkable fact is that while so many fore-shocks preceded the first big disturbance, the three other forcible earthquakes came independently without any fore-shocks.

The After-shocks. Soon after the destructive earthquake of Nov. 26, two seismographs were installed at Hiyekawa and at Tanna Basin with the object of forming a net of four stations for determining the three dimensional positions of the seismic foci as well as their depths.

Distribution of the After-shocks. As indicated by the small circles in Fig. 5, the after-shocks are clustered near Aziro and distributed along

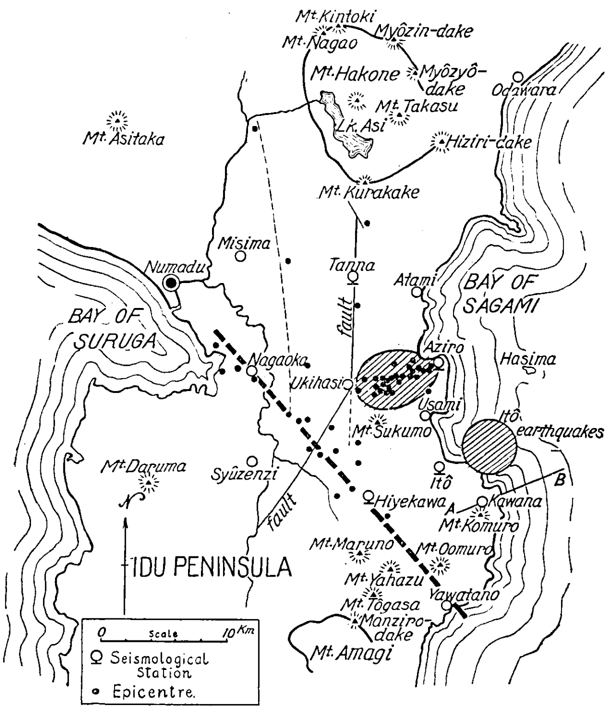


Fig. 5. Distribution of the after-shocks of the Idu earthquake.

the imaginary line drawn cutting the Peninsula in a N.W. to S.E. direction. Those clustered near Aziro exhibit the same peculiarities as those that clustered themselves near Itô after Feb. 10. This phenomenon may be explained as the continuation of the seismic activities resulting from the migration in a N.W. direction of the seismic centre that was active at Itô 8 kms. distant. The other after-shocks that arranged themselves on the N.W.-S.E. line just mentioned are fresh and independent outbreaks.

The Idu Seismo-tectonic Line. Dr. Ogawa postulates his 'seismo-tectonic' line for any particular region by the intensities of earthquakes that prevail there (judged by the damage wrought) and not by their frequency. That faults should characterize such weak lines hardly needs remarking. As such line in the Idu Peninsula he cites several that run meridionally and also across the Peninsula from N.W. to S.E. Forming on of the last-mentionad lines is the Nagaoka-Yawatano line of weakness as deduced from our investigation of the distribution of after-shocks; a seismo-tectonic line that we have found to exist in reality. On joining the two earthquake clusteres of Itô and Aziro from centre to centre, the line lies parallel to the Nagaoka-Yawatano line of weakness that runs obliquely across the Peninsula from N.W. to S.E.

The Tanna fault is a meridional weak line showing itself for the most part in the Tanna tunnel lying 150 m. below the ground surface of the Tanna Basin, and which was displaced in the earthquake under discussion 240 cms. horizontally with a downthrow of 60 cms. In the neighbourhood of this fault after-shocks were rare. There is another tectonically weak line parallel to the Tanna fault at a distance of 10 kms., which extending upwards, passes between the Hakone mountains and Huzi, both dormant volcanoes. On this line, after-shocks have occurred but not in any great number.

It is interesting to note that after-shocks have occurred also on the bottom of Sagami Bay.

Relation between the Earthquakes and the Tide-level. As will be seen from Fig. 6, the hourly earthquake frequencies at Itô corresponded with certain phases of the tide-level. For instance, upon comparing the frequency curve (See Fig. 6) with the mareogram curve obtained at the Misaki Tide Station, it will be seen that times of low water corresponded with high earthquake frequency. This was the case also with the earthquakes that started to disturb Idu since Nov. 7. (See Fig. 7.) The main big shock of Nov. 26 came two hours after time of lowest tide,

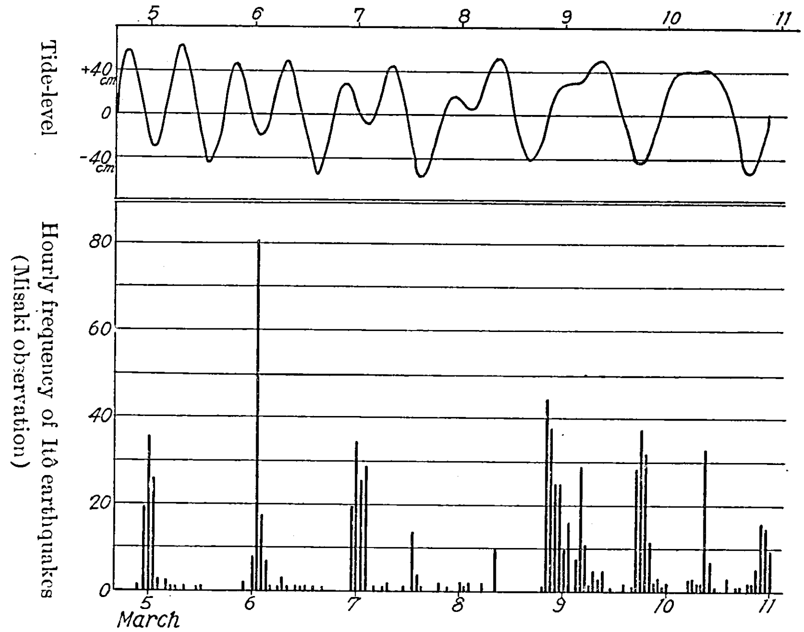


Fig. 6 shows the relation between the tide-level and the hourly frequency of the Itô earthquakes.

when the tidal load was comparatively small. This correspondence, though well-marked during the earlier onsets of the swarms of small shocks, gradually disappeared so that in time the relationship ceased to hold. At all events, the inference is that withdrawals of the tide load during the earlier periods of the earthquake activities were the trigger actions that set in motion the daily earthquake swarms. On the next page is a table of the hourly frequencies of the fore-shocks recorded at Itô.

As to the relation of earthquakes to atmospheric changes, our studies failed to produce any definite results, which is owing probably to our having so far availed ourselves of meteorological data covering Itô only, whereas if data from a few more stations were available some interesting results might have been obtained.

Earthquake swarms as mentioned in the preceding paragraphs are common occurrences before a volcanic eruption. The Idu Peninsula, as is well known, lies on the volcanic line beginning with Mt. Huzi and extending into the Pacific as far as the Sititô group of Islands. In the Peninsula itself are three large dormant volcanoes besides a number of

Table I. Hourly Frequency of the Fore-shocks.

Time \ Date	November.																				
	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	
h h																					
0—1	0	0	0	0	0	0	1	1	1	2	0	0	0	0	8	1	1	0	1	5	
1—2	0	0	0	0	0	0	1	1	0	2	1	1	0	17	3	3	1	4	1	38	
2—3	0	0	0	0	0	16	0	1	0	0	1	2	1	36	2	3	2	13	1	5	
3—4	0	0	0	0	0	29	0	1	0	0	6	4	?	4	0	0	5	2	0	3	
4—5	0	0	0	0	0	5	4	1	0	0	0	22	?	6	0	1	8	2	3	{destructive earthquake	
5—6	0	2	0	0	0	3	33	1	0	0	80	6	0	0	1	3	5	3	5		
6—7	0	0	0	0	0	2	2	0	0	1	27	0	1	2	0	1	21	1	2		
7—8	0	0	0	0	11	3	0	0	0	3	2	0	3	0	2	2	67	2	4		
8—9	0	0	0	0	1	4	1	0	0	17	6	1	0	0	0	4	44	1	2		
9—10	0	1	0	0	4	1	3	0	1	119	2	0	0	1	0	1	33	1	10		
10—11	0	0	0	0	1	0	11	2	2	63	1	0	0	1	11	0	17	0	9		
11—12	0	0	0	0	1	1	9	2	0	28	3	0	0	0	41	1	14	0	3		
12—13	0	0	0	0	0	2	1	3	0	42	3	0	0	1	16	2	10	4	3		
13—14	0	0	0	0	0	1	0	0	0	11	3	2	1	2	3	0	2	1	8		
14—15	0	0	0	0	0	1	1	6	2	7	1	0	1	0	2	5	7	21	127		
15—16	1	0	0	0	1	2	1	?	4	2	6	0	2	0	4	26	0	14	162		
16—17	0	0	0	0	0	4	1	?	14	4	18	0	3	0	4	19	0	4	145		
17—18	0	0	0	0	0	3	1	12	48	4	4	?	4	2	8	1	6	3	76		
18—19	0	0	0	0	0	1	2	2	39	3	1	?	3	40	4	4	3	3	36		
19—20	0	0	0	0	0	12	8	?	?	0	0	?	0	236	7	2	4	1	49		
20—21	0	0	0	0	0	40	79	?	?	0	3	?	1	123	209	3	4	1	12		
21—22	0	0	0	0	0	17	13	0	3	2	3	3	0	71	152	3	2	1	15		
22—23	0	0	1	0	0	1	0	2	1	3	4	0	0	18	98	2	2	2	9		
23—24	0	0	0	0	0	1	1	1	?	6	2	0	1	5	48	0	3	0	7		Total
Daily Total	1	3	1	0	19	149	173	36	115	319	177	41	21	565	623	87	261	84	690	51	3411

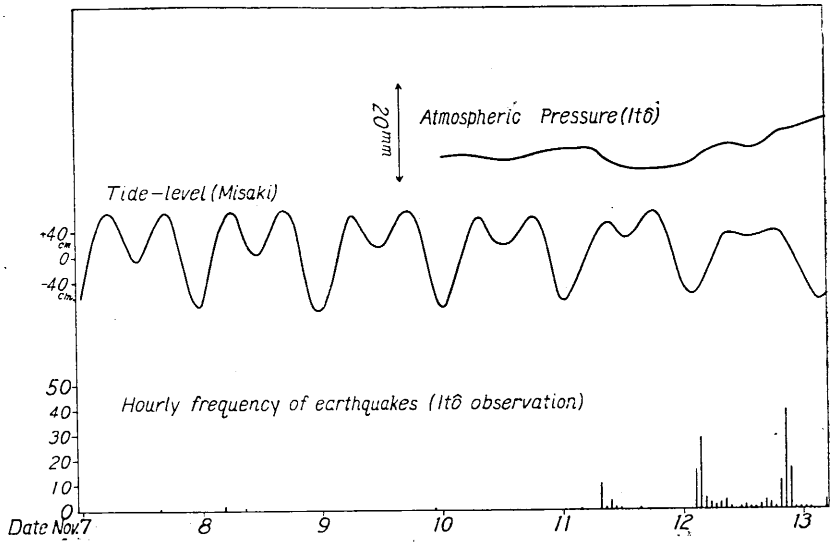

Atmospheric Pressure (Itô)
20mm
Tide-level (Misaki)
+40 cm
0
-40 cm
Hourly frequency of earthquakes (Itô observation)
50
40
30
20
10
0
Date Nov. 7
8
9
10
11
12
13

Fig. 7 (a).

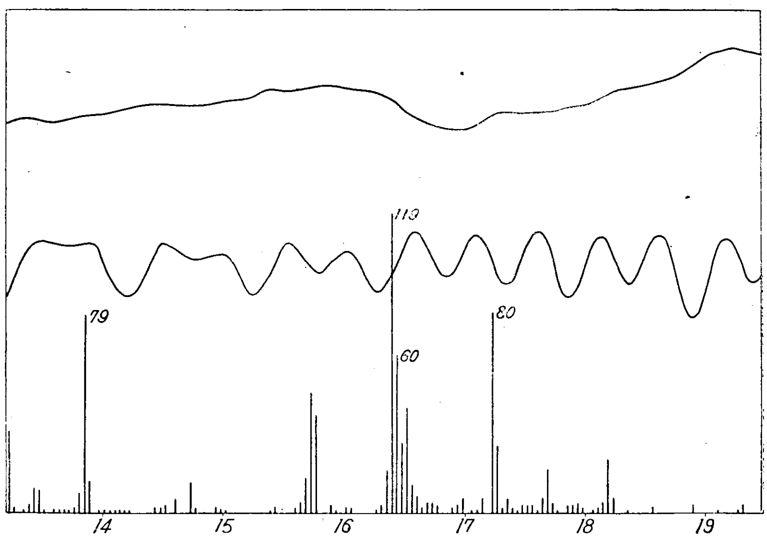

113
79
80
60
14
15
16
17
18
19

Fig. 7 (b)

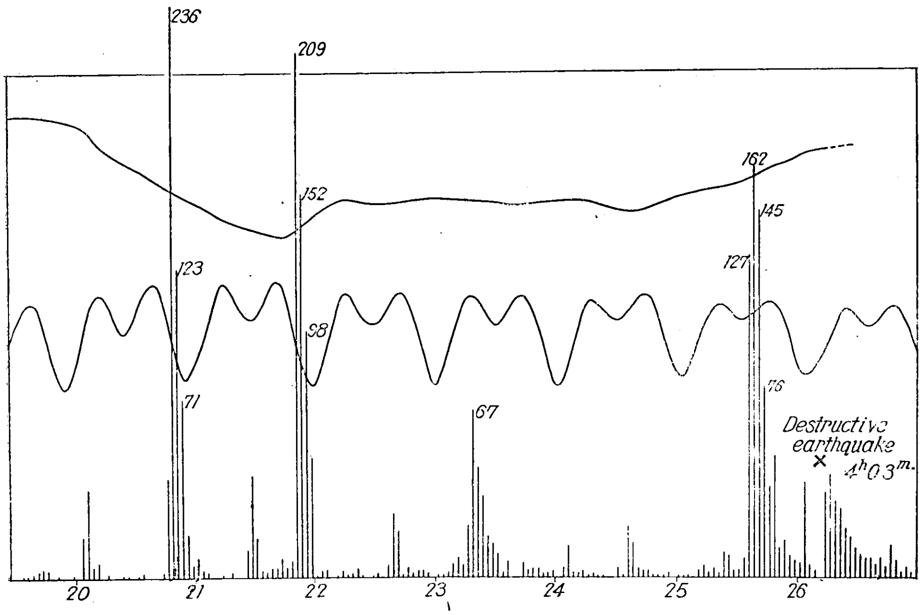


Fig. 7 (c).

minor secondary cones, and Itô itself is not far from what geologists have found to be the remains of an ancient crater a few square kms. in area.

From the distribution of foci of the Itô earthquakes, the swarms of shocks, and the relation of the earthquakes to phase of tide level, there is little room for doubt that the recent seismic disturbances there are attributable to the sudden activities of a volcano hidden under the bay of Itô.

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2. 伊豆半島に於ける最近の地震活動に就いて (其一)

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岸上冬彦
小平孝雄

昭和五年二月十三日から伊東地方に地震が頻發した、筆者等は先年の丹後大地震の餘震觀測に則つて伊東を中心として五箇所に臨時觀測所を設けて震原の分布を調査した。卽ち伊東、川奈初島、宇佐美、網代の觀測より震原の分布は一つの漏斗狀をなす範圍と相模灣の陷沒地帶より初まり伊豆半島をほぼ東西に横切る弱線に起つてゐたことが判つた。なほ震原分布研究を進めて關

東大地震の震原と伊東地震の震原とが如何なる位置的關係にあるかといふことにまで言及した。伊東地震は二月より三月末に至る間及五月中は最も活動したが八月に至つて全く平靜になつた。

突然十一月七日より再び網代附近に地震を感じ性質も伊東地震に類似するものであることが判たつが震原位置の測定のために再び觀測點を設置することになり伊東網代に器械を据へ終つたときに伊豆大地震となつた。それより餘震觀測を上の二箇所と丹那、冷川、吉原に於て行ふことゝした。その結果伊豆半島を西北より東南に横切る線にそつて餘震が起つてゐることを知つた。勿論この外にも伊東地震の繼續とも見るべき地震群が網代附近にも盛んに起つてゐた。

大地震の前震に就いて一時間毎の回數の統計をとり三崎に於ける檢潮儀の記錄と比較して矢張り伊東地震の際の如く低潮位のときに地震回數が相當多いことを知つた。