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12. *On the Changes in the Heights of Mean Sea-levels, Before and After the Great Niigata Earthquake on June 16, 1964.**

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Introduction

The valuable data for mean sea-level, as well as mean sea-water temperature and barometric pressure at Nezugaseki and Kasiwazaki was kindly placed at my disposal by the Agency of Geographical Survey Institute, for which I wish to express my hearty thanks.

Dr. I. Tsubokawa and Mr. T. Hayashi of the Geographical Survey Institute have obtained the amount of subsidence of the ground near Nezugaseki to be about 120 mm on the occasion of the Niigata Earthquake from the tidal curves at Nezugaseki and at Kasiwazaki, assuming Kasiwazaki is unchanged.

I have also calculated the amount of the corresponding ground movement by applying the same method as that used in the case of detecting the amount of depression of the datum line on Standard Bench Mark at Miyakezaka in Tokyo by utilizing fluviographic records on the occasion of the Kwanto Great Earthquake, Sept. 1, 1923.

In that particular case, I have detected the amount of depression, about 90 mm, which pretty well coincided with that of the result of Levelling Survey, 86 mm, carried out by the Land Survey Department.[1)]

Method of Investigation and Results

The measurement of fundamental elements to certify the standard original line in tidal record as correct, was fortunately carried out at 16 h 25 m on 14, June, 1964, about 45 hours preceeding the Niigata Earthquake by the Agency of Geographical Survey Institute.

Consequently, we have taken the mean of sea-level during 45 hours

* Communicated by H. Kawasumi.

1) S. Yamaguti, *Bull. Imp. Earthq. Inv. Comm.*, XI (1928), No. 3.

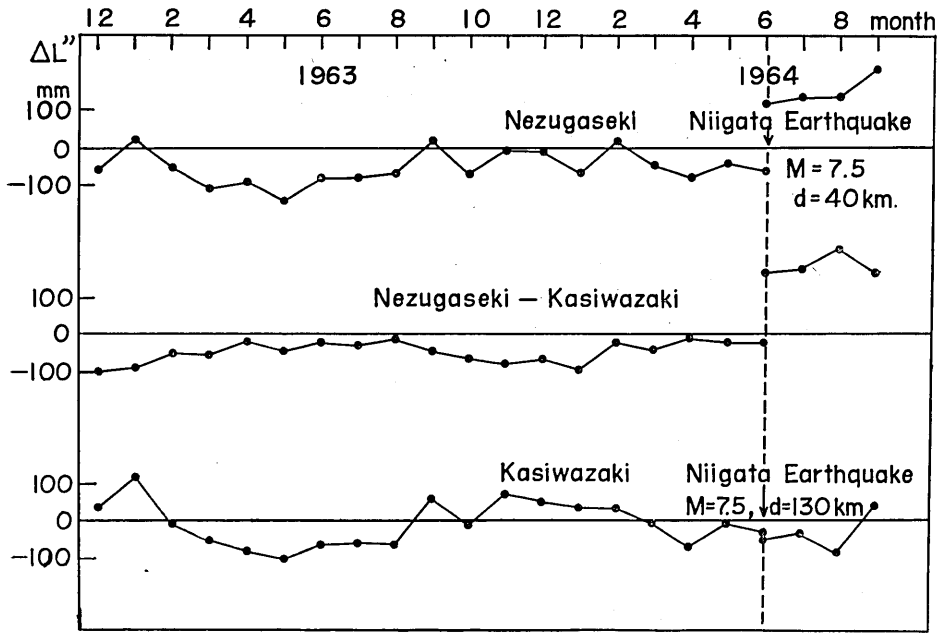

Fig. 1. Change in the height of monthly mean sea-level before and after the Niigata Earthquake, which occurred on June 16, 1964.

from that date of the fundament measurement to 13 o'clock on 16, just preceeding the Earthquake, and obtained the mean value of 133.3 cm measured from the upper reference line. Immediately after the Earthquake, the ocean waves (or Tunami) attacked the Bay of Nezugaseki and seemed to have carried the water mass into the Bay, consequently, we have taken the mean of sea-level for 45 hours from about 8 hours after the Earthquake, to 16 o'clock on 18, and obtained the corresponding mean value of 99.9 cm.

Thus, we have the value of the difference $\Delta L = 1133 - 999 = 134$ mm, which is the amount of the rise of mean sea-level, or the subsidence of the ground relative to the mean sea-level.

On the other hand, half-monthly mean sea-levels from 1 to 15 June, as well as from 17 to 30 of that month, were calculated by the same method as already reported in my paper.[2)]

Here, the explanation as to the monthly mean sea-levels, corrected, $\Delta L''$ for Aburatubo will be repeated briefly. The monthly deviation of mean sea-level from annual mean for 40 years, may be denoted by $\Delta L'$

2) S. YAMAGUTI, *Bull. Earthq. Res. Inst.*, 38 (1960).

and next, the value of $\Delta L''$ with residual corrections due to sea-water temperature, and barometric pressure, was calculated by the formula $\Delta L''=\Delta L'-q\Delta T'-p\Delta b'$, here $\Delta T'$ and $\Delta b'$ are the monthly deviations from annual mean of sea-water temperature and barometric pressure during the period of 40 years, corresponding to $\Delta L'$ respectively.

The values of the corrected mean sea-levels, for Nezugaseki $\Delta L''=$ 118 mm for the latter, and $\Delta L''=-59$ mm for the former in June, were obtained respectively. The value of the difference is $\delta\Delta L''=118-(-59)=$ 177 mm. The result equals the subsidence of the ground, in amount, 177 mm relative to the mean sea-level, during half the month of June. Moreover the values of monthly mean sea-levels, corrected, for successive months, July, August and September, 1964, were calculated by exactly the same method as above cited. The results have shown that, in July, the subsidence of the amount of crust 17 mm, continued but in August it practically, stoped, and in September, the subsidence ef the crust of the amount, 72 mm, continued again as shown in Fig. 1, a.

The difference in the heights of mean sea-levels between Nezugaseki and Kasiwazaki for about half a month before and after the Niigata Earthquake, were calculated similarly as before, and the value of $\delta\Delta L''_{N-K}=$ $161-(-23)=184$ mm was obtained, which is nearly equal to the above value, 177 mm, as shown in Fig. 1, *b*. As the amount of the change in the height of a half-monthly mean sea-level for Kasiwazaki itself, the value of $\delta\Delta L''=-43-(-36)=-7$ mm was obtained, which may be recognized also from the trace on the mareographic record, shown in Fig. 2. This result means the upheaval of the ground relative to mean sea-level. In July, the value of the difference between two stations, $\delta\Delta L''_{N-K}=14$ mm was calculated, but in August and in September, they showed a pretty large difference in value, from those for Nezugaseki, itself, these being, $\delta\Delta L''_{N-K}=47$ mm and -60 mm, owing to the depres-

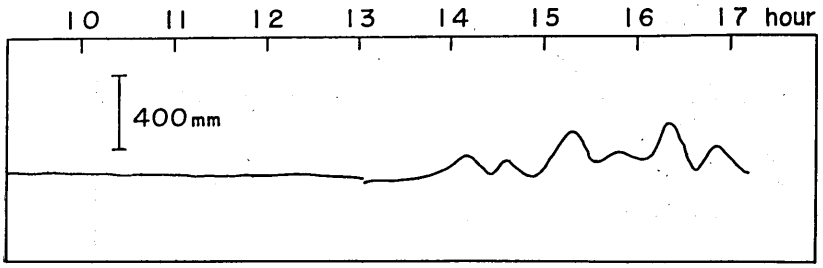

Fig. 2. Mareographic record at Kasiwazaki on the day of the Niigata Earthquake (June 16, 1964).

sion −46 mm and rise 132 mm in a large amount of the curve for Kasiwazaki, respectively, not withstanding, the values of $\delta\Delta L''=1$ mm and 72 mm for Nezugaseki itself. This fact may be considered to show an apparently large subsidence and even a rise of the earth's crust near Nezugaseki, relative to that near Kasiwazaki. Thus, the method of taking the difference of mean sea-levels between two mareographic stations to detect the movement around may be applied only in the case in which any one of the stations is confirmed as being unchanged.

The changes in the heights of monthly mean sea-levels at Nezugaseki and Kasiwazaki for 18 months before the Niigata Earthquake are shown in Fig. 1, the feature of which resembles the result of the statistics, having taken the great earthquakes, 103 in number, with magnitude, $M\geqq 7$, in Pasadena Scale as already reported in my paper[2] above cited. Namely, the curve of monthly mean sea-level reaches maximum, in the month of 4, and becomes minimum in the month of 2 or 1 before the earthquake.

Lastly, yearly mean sea-levels for Kasiwazaki as well as Nezugaseki were calculated from the values of monthly mean sea-levels, corrected, and plotted against the years as shown in Fig. 3. The curve for Nezu-

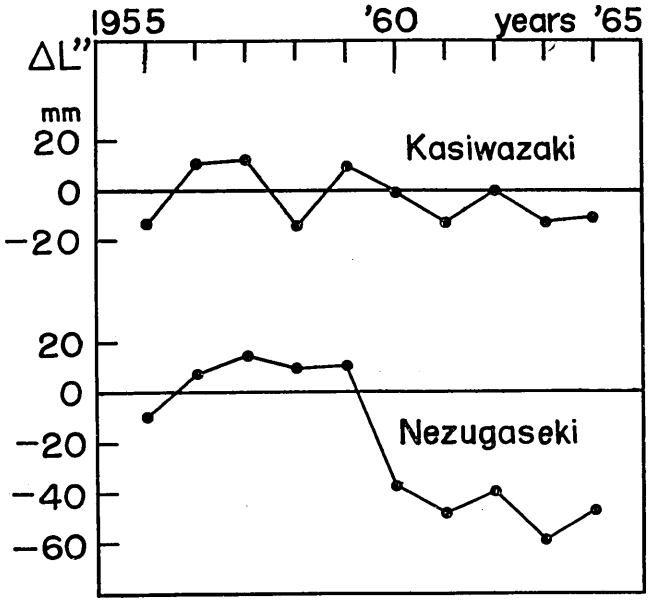

Fig. 3. Change in the height of yearly mean seal-level before the Niigata Earthquake, on June 16, 1964.

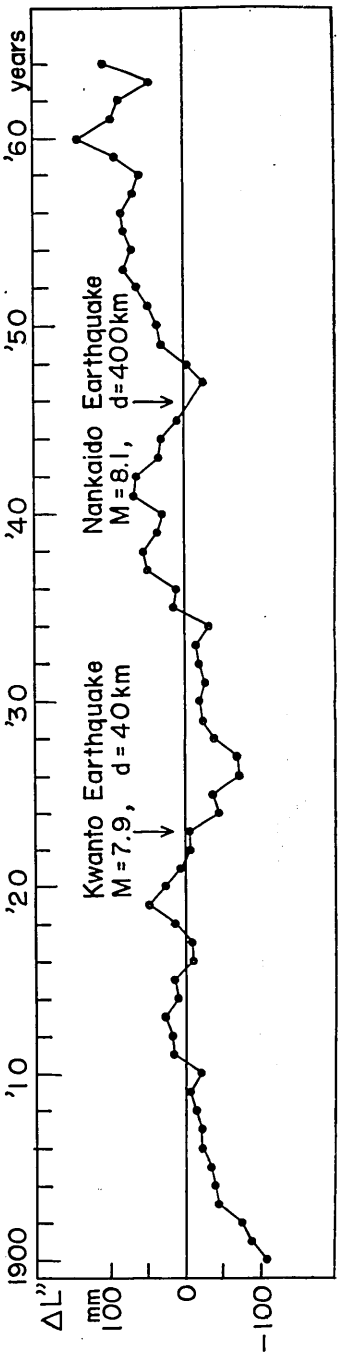

Fig. 4. Yearly mean sea-level, at Aburatubo calculated from $\Delta L''$.
M=magnitude of the earthquake. d=epicentral distance

gaseki with epicentral distance about 40 km, has begun to descend quite conspicuously from 5 years before the Niigata Earthquake, compared with that for Kasiwazaki, with epicentral distance, about 130 km. Similar facts were already observed in the cases of the Great Kwanto Earthquake, with magnitude 7.9, epicentral distance, about 40 km, as well as the Great Nankaido Earthquake, with magnitude 8.1, epicentral distance about 400 km, for the diagram of yearly mean sea-level at Aburatubo, as shown in Fig. 4, in which, most parts of the diagram for 1900–1959 were redrawn, the last part of the diagram for 1960–1964, being newly drawn here.

These three actual examples may be worth utilizing to predict a great earthquake by observing the yearly mean sea-level, corrected, taken from tidal records.

The diagram for yearly mean sea-level at Aburatubo, shows a continuously ascending tendency from the year 1947 (after the Nankaido Earthquake) to the year 1960 (reaching maximum) and then begins to descend to the year 1963 and again tends to ascend to the year 1964, being observed by people with an interest in the future.

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12. 新潟地震前後の平均海水面変化について

山 口 生 知

1. 関東大地震のときに東京近在の 20 箇所の験潮記録を用いて，三宅坂の水準原点が約 90 mm 下つたことを結論した．その値は翌月陸地測量部から発表された 86 mm とよく一致した．そのときと同様の方法で震源から 40 km はなれた鼠ケ関の地盤が地震と同時に 134 mm 沈下したことを計算で出した．

2. 地震前半月の平均と地震後半月の平均の海水面の高さを諸修正を施して計算すると 177 mm 地盤沈下という値が出た．これは地震後も沈下を続けて，その量が増したと考えられる．而して 7 月には更に 17 mm 沈下を続け，8 月には一旦止つて 9 月になつて再び 72 mm 沈下したことが計算された．

3. 鼠ケ関と共に震源より約 130 km はなれた柏崎の年平均海水面の変化も調べてみた．その結果は第 3 図に示されるように，柏崎に比べて鼠ケ関では明瞭に 5 年ほど前より著しい平均海水面の沈降を示している．この現象は関東地震の際にも，また南海道地震の際にも，油壺の年平均潮位曲線に表われていた．

以上三つの事実は将来地震予知に関する研究に役立つものと思われる．