BULLETIN OF THE EARTHQUAKE
RESEARCH INSTITUTE
Vol. 43 (1965), pp. 149-159

# 10. *On the Tsunami which accompanied the Earthquake off the Northwest of Oga on May 7, 1964.*

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(Read Oct. 27, 1964.—Received Dec. 19, 1964.)

## Abstract

The tsunami, which was generated off the northwest of Oga Peninsula in Akita Prefecture, at 16h 58m 7.7s (JST), May 7, 1964, was observed at many tide-gauge stations along the coast of the Japan Sea. The heights of tsunami were small. The epicenter of the earthquake was at 40°20′N, 139°00′E, with a depth of 0 km and magnitude 6.9.

The generating area of tsunami, which was extended 50~70 km was estimated by means of an inverse refraction diagram from eight tide-gauge stations. At all the stations inspected, the initial motion of the tsunami was found to be directed upwards, showing that the crustal deformation which caused the tsunami was probably an upheaval in the source area. Generally speaking, the upheaval seems to have been small but somewhat conspicuous in the northeastern part of the tsunami source area.

At 16h 58m 7.7s (JST), May 7, 1964, there occurred a strong earthquake off the northwest of Oga Peninsula in Akita Prefecture. According to the Japan Meteorological Agency, the magnitude of the earthquake was 6.9, the depth 0 km and epicenter being at 40°20′N, 139°00′E. Reclaimed land at Hachiro-Gata in Akita Prefecture was considerably damaged.[1] Accompanying this earthquake, a small tsunami was generated and observed along the northern coast of the Japan Sea. Fig. 1 shows the distribution of double amplitude (cm) of the maximum sea disturbance. A recent tsunami occurred at the time of the Oga earthquake on May 1, 1939.[2] Compared with the 1939 tsunami, the

1) S. NAGUMO, "Field Studies of the OGA-OKI Earthquake of May 7, 1964," *Bull. Earthq. Res. Inst.*, **42** (1964), 597, (in Japanese).

2) F. KISHINOUYE and K. IIDA, "The Tunami that accompanied the Oga Earthquake of May 1, 1939," *Bull. Earthq. Res. Inst.*, **17** (1939), 733.

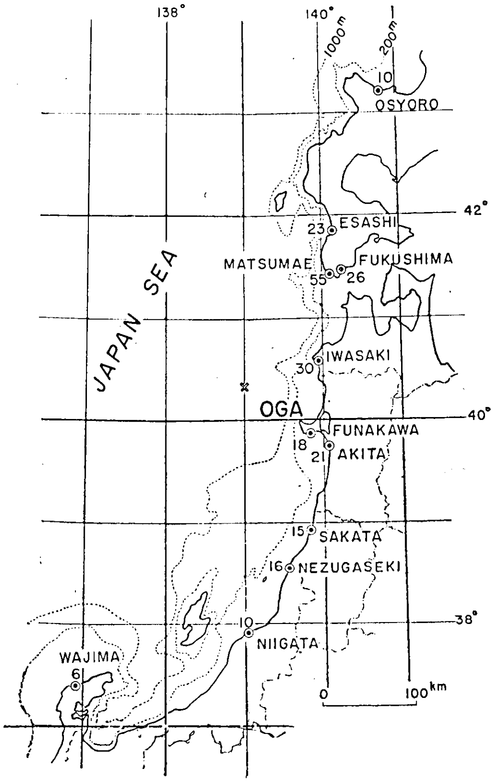


Fig. 1 Distribution of double amplitude (cm) of the maximum sea disturbance of the tsunami of May 7, 1964.

present one had almost the same intensities at the tide-gauge stations on the coast of the Japan Sea. The present tsunami was small. The phenomena, therefore, are investigated with the aid of thirteen tide-gauge records as shown at Figs. 5~8 without field investigation. An arrow in Figs. 5~8 shows the time of commencement of tsunami.

Fig. 2 shows the profile for summary report on the tsunami observation from Osyoro to Wajima, where the initial wave-height and the maximum height are above ordinary tidal level and at double amplitude of the sea disturbance respectively. Travel time, +, and the period between the first and second crests on the tide-gauge records, △, are shown in Fig. 2. The initial motion of the tsunami is *up* everywhere. The periods are about 12 min along the coast near the tsunami source. Features of the tsunami at different localities can be seen in Table 1.

Inversed refraction diagrams were drawn starting from eight tide-

Table 1. The tsunami of May 7, 1964, as recorded by tide-gauges. (All times are Japan Standard Time)

| Tide station | Initial wave | | | | Maximum wave | | | |
|---|---|---|---|---|---|---|---|---|
| | Arrival time | | Height* | Period | Occurred time | | Height** | Period |
| | h | m | cm | min | h | m | cm | min |
| Osyoro | 18 | 23 | 4 | 26 | 20 | 10 | 10 | |
| Esashi | 17 | 28 | 5 | 12 | 19 | 05 | 23 | 11 |
| Matsumae | | | 7 | | 17 | 30 | 55 | |
| Fukushima | 17 | 36 | 12 | 11 | 18 | 44 | 26 | 12 |
| Iwasaki | 17 | 15 | 10 | 12 | 18 | 40 | 30 | 11 |
| Noshiro | 17 | 28 | | | | | | |
| Funakawa | 17 | 28 | 11 | 12 | 18 | 13 | 18 | 12 |
| Funakoshi | 17 | 38 | 10 | 14 | | | | |
| Akita | 17 | 38 | 9 | 18 | 17 | 40 | 21 | 18 |
| Sakata | 17 | 40 | 4 | 18 | 18 | 20 | 15 | 13 |
| Nezugaseki | 17 | 48 | 5 | 8 | 19 | 17 | 16 | 10 |
| Niigata | 17 | 58 | 3 | 17 | 19 | 00 | 10 | 13 |
| Wajima | 17 | 45 | 2 | | 19 | 45 | 6 | |

* Crest-height above the ordinary tidal level.
** Double amplitude.

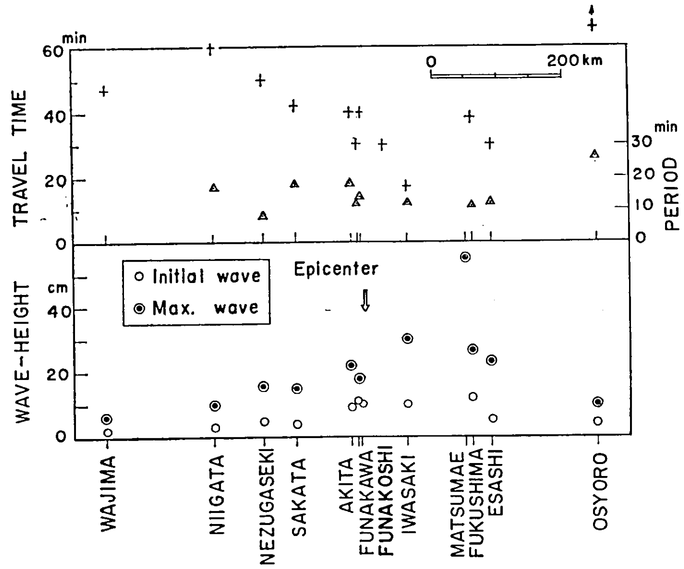


Fig. 2 Profile of the tsunami from Osyoro to Wajima. (+: Travel time, △: Period)

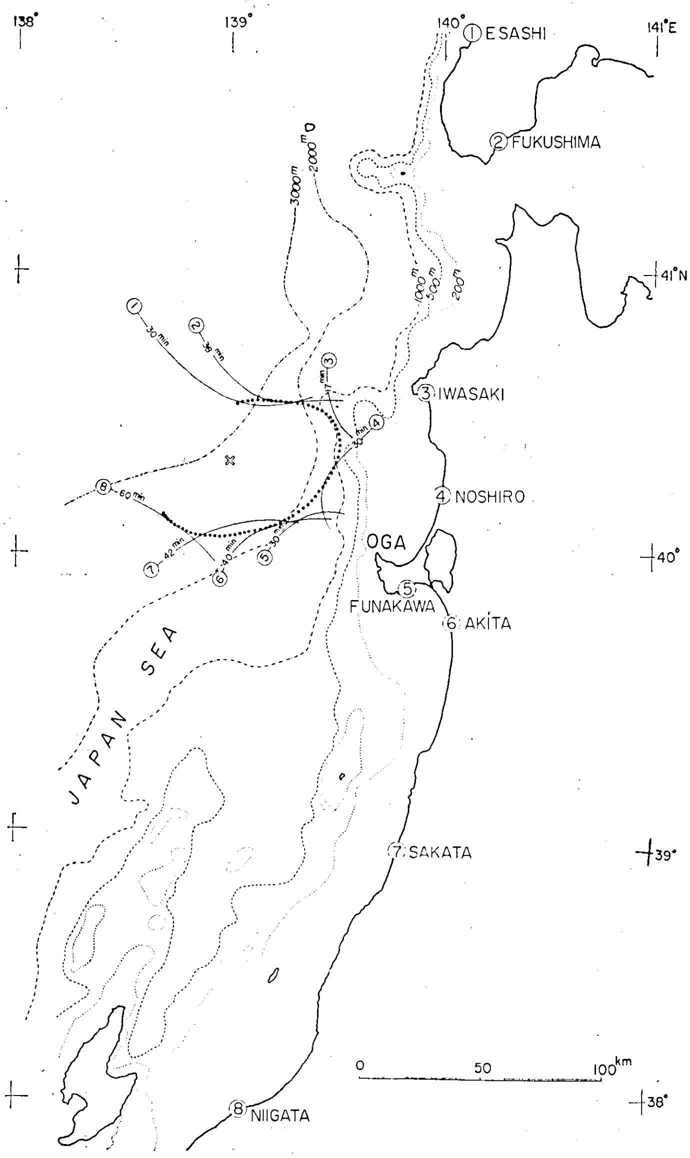


Fig. 3 Generating area of the tsunami.

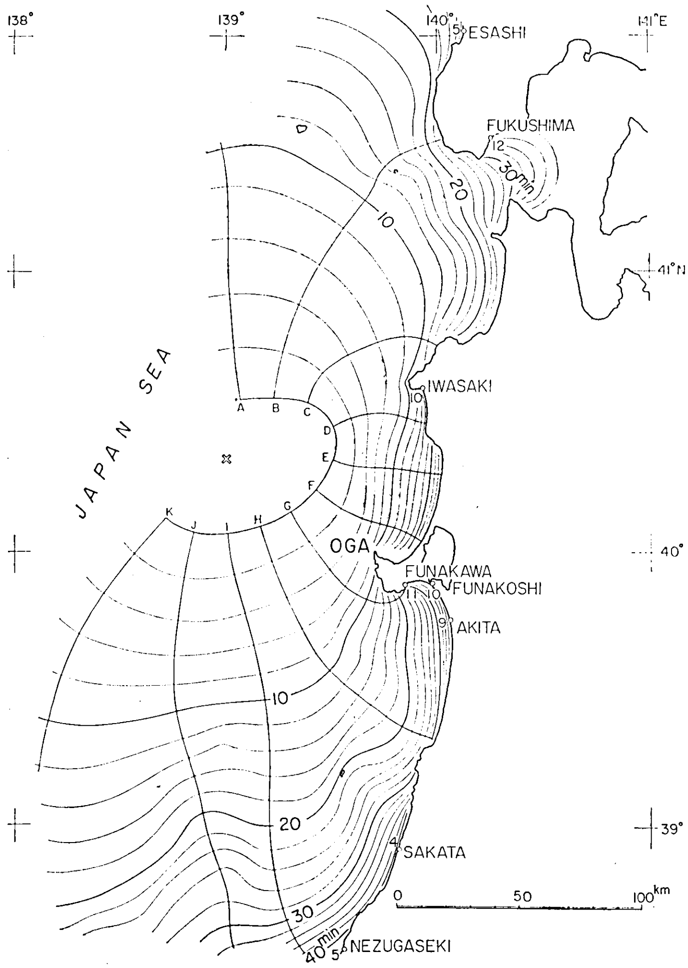


**Fig. 4 Refraction diagram and distribution of the initial wave-height (cm).**

gauge stations at Esashi, Fukushima, Iwasaki, Noshiro, Funakawa, Akita, Sakata and Niigata, as shown in Fig. 3. Wave fronts have been drawn at every two minute intervals, but in Fig. 3 only the final wave front corresponding to the travel time is shown. The area of tsunami source includes the epicenter of main shock, but the western part of the source cannot be decided. The linear dimension of the tsunami domain is about $50\sim70$ km.

This generating area of tsunami corresponds approximately to the area of aftershocks as estimated by means of the P-wave data observed

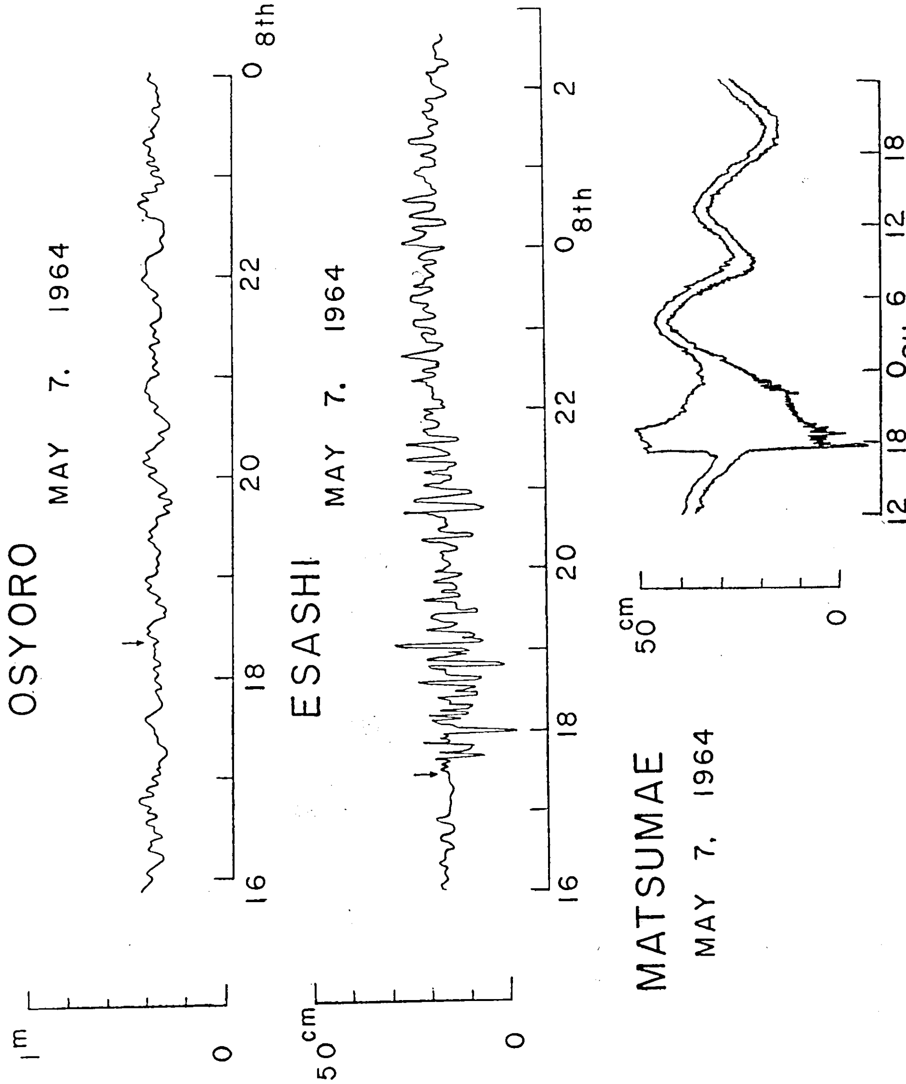


Fig. 5 Tide-gauge records at Osyoro, Esashi and Matsumae.

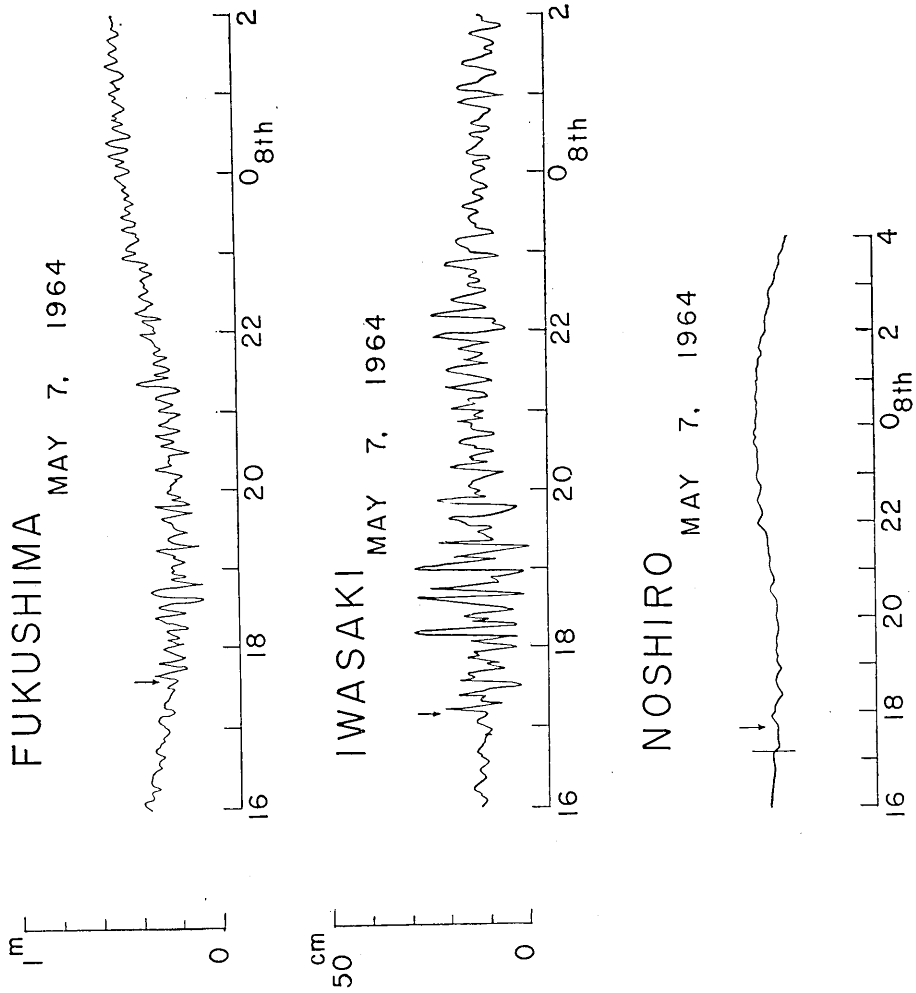


Fig. 6 Tide-gauge records at Fukushima, Iwasaki and Noshiro.

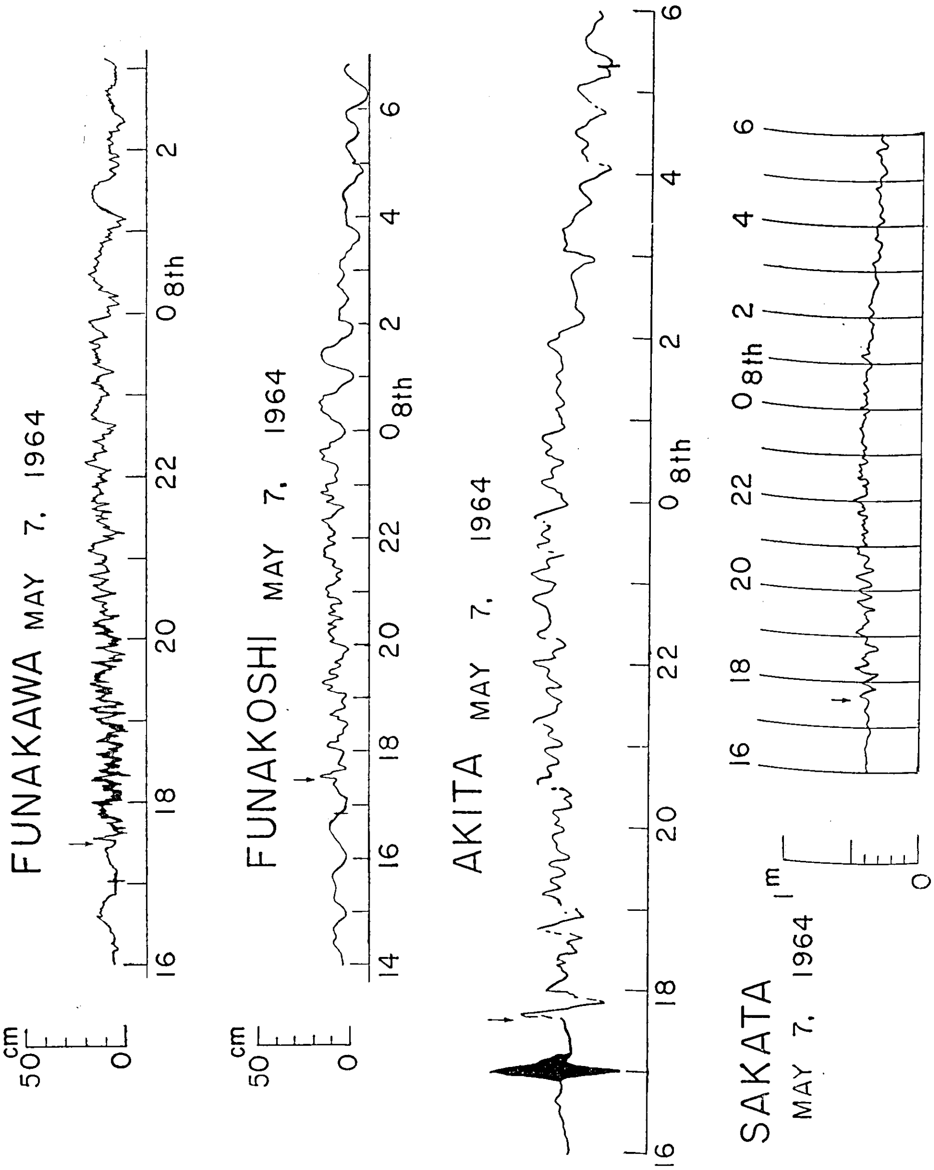


Fig. 7 Tide-gauge records at Funakawa, Funakoshi, Akita and Sakata.

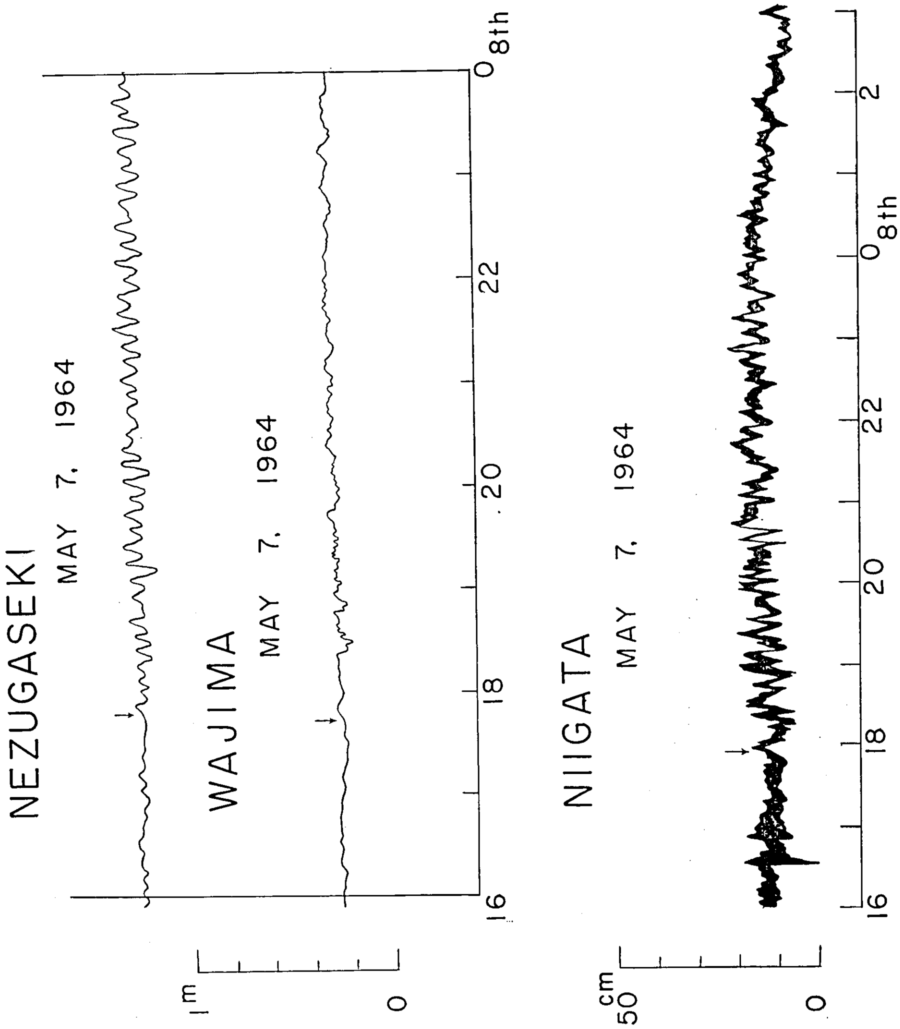


Fig. 8 Tide-gauge records at Nezugaseki, Wajima and Niigata.

by research groups of Tohoku University.[3] However, the aftershock area estimated by means of the PS-time data is somewhat smaller than the former estimate and lies in the eastern region of the main shock extending northeastward. This aftershock area is again inside the generating area of tsunami.

On the tsunami dued to the Niigata earthquake,[4] the distribution of wave-height along the coast near the generating area of tsunami corresponded approximately to the bottom deformation. Motion of the present tsunami source has probably been an upheaval judging from the tidal records, so that the upheaval seems to be conspicuous at the northeastern region in the tsunami source. The wave-heights of the northeastern coast are higher than those near the tsunami source as shown in Figs. 1, 2.

In order to consider the tsunami energy emitted from the source towards the coast, a refraction diagram was drawn as shown in Fig. 4. Starting from the margin of the tsunami source area estimated at Fig. 3, wave fronts have been drawn at every two minute intervals. The azimuth at the margin of the source was divided by ten equal widths (13.5 km). Using the distribution of initial wave-height along the coast, wave-height on the circumference of the source is estimated by means of the Green's law which states $\eta \propto h^{-\frac{1}{4}} l^{-\frac{1}{2}}$, where $h$ is depth and $l$, the width between the two trajectories. As the result of calculation, wave-height at B–C, C–D, G–H and H–I in Fig. 4 are obtained as 7, 4, 5 and 3 cm respectively, where the depth near the coast is assumed to be 5 m and the width between two of the trajectories at the coast is measured along the smooth coast line. From this result the bottom deformation seems to be conspicuous in the northeastern region of the source in correspondence with the data of the distribution of aftershock decided with PS-time.

The heights of the present tsunami have been small in relation to the magnitude of the earthquake. According to K. Iida's statistical formula,[5] the wave-height was expected to be about 1 m. Therfore,

3) TOHOKU UNIVERSITY, "Report on the Observation of Aftershock off Western Aomori on May 7, 1964," Paper to be read at the Seism. Soc. Japan Meeting, Kanazawa, 1964.

4) T. HATORI, "On the Tsunami which accompanied the Niigata Earthquake of June 16, 1964, Source Deformation, Propagation and Tsunami Run-up," *Bull. Earthq. Res. Inst.*, **43** (1965), 129.

5) K. IIDA, "Magnitude and Energy of Earthquakes accompanied by Tsunami and Tsunami Energy," *J. Earth Sci., Nagoya Univ.*, **6** (1958), 101.

the present tsunami seems to be rather small for such a magnitude of earthquake. The bottom deformation seems to be small, because the aftershock were preminently occurred 40 km depth.

In conclusion, the author wishes to express his hearty thanks to the offices concerned for putting their tide-gauge records at the author's disposal. His thanks are also due to Prof. R. Takahasi for his guidance.

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## 10. 昭和39年5月7日の男鹿北西沖地震の津波について

地震研究所　羽 鳥 徳 太 郎

昭和39年5月7日16時58分7.7秒，男鹿半島沖に発生した地震で，(気象庁によれば，40°20′N, 139°00′E, $h$=0 km, $M$=6.9) 秋田県八郎潟干拓地域に可成りの被害を与えた.

この地震に伴ない軽微な津波が発生し，北海道南西部，東北地方西部沿岸における最高波高 (全振幅) 分布は Fig. 1 のようになり，昭和 14 年 5 月 1 日男鹿地震の津波とほぼ同程度の規模である. 従つて今回の津波は検潮儀で計測し得る程度の大きさのため，現地調査を行わず各地から収集した 13 箇所の検潮記録について検討した.

津波の初動は各地すべて"押し"で始り，Table 1 は各記録の読取値を示すが，津波概要を忍路一輪島を結ぶ線上に図示すると Fig. 2 のようになる. 図中，波高について，第 1 波は気象潮上の片振幅，最高波は全振幅を示し，伝播時間は記号 ＋ で，第 1 波の周期は記号 △ で表わし浪源近接地域では約 12 分である.

津波初動の各地到達時間は，検潮記録から江差 30 分，福島 38 分，岩崎 17 分，能代 30 分，船川 30 分，秋田 40 分，酒田 42 分および新潟 60 分である. これらの到達時間をもとにして津波の逆伝播図を作り，浪源域を推定すると Fig. 3 のようになる. この浪源域は本震震央を含み領域の長さは 50〜70 km である. 東北大学の余震観測報告によれば，$P$ 波から求めた余震域は推定浪源域とほぼ一致し，PS タイムから求めた余震域は本震震央より東側の浪源域内で北東方向に分布している.

波高は Figs. 1, 2 に示すように，浪源の近接沿岸より北東方向の北海道渡島半島沿岸地域が高い. 浪源からの津波エネルギーの配分を検討するため，Fig. 4 に示すように推定浪源からの伝播図を作り，浪源周囲を 10 等分 (13.5 km) して，これから放射線を画くと，北海道南西部地域に特別津波エネルギーの集中は認められない.

浪源周囲の波高を Green の方法で，第 1 波の波高分布から推定すると，Fig. 4 において B-C 間 7 cm, C-D 間 4 cm, G-H 間 5 cm および H-I 間 3 cm となる. 一方，津波初動から海底の上昇運動が推測され，且つ余震観測結果から海底変動は，浪源内の北東領域が顕著であつたと思われる. しかしながら波高は飯田 (1958) の地震と津波のマグニチュードの関係式から予想されるものに比して小さく，余震の深さは 40 km が卓越したことから，海底変動はこの地震のマグニチュードとしては極めて小さかつたであろう.