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31. *Tsunami Sources in the Sanriku Region in 1979 and 1981, Northeastern Japan—Seismic Gap off Miyagi.*

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Abstract

Two small tsunamis generated far off Iwate on Feb. 20, 1979 and off Miyagi on Jan. 19, 1981 are investigated, by using the tide-gauge records. From the amplitude-distance diagram, the magnitude (Imamura-Iida scale: m) of the 1979 and 1981 tsunamis are determined to be $m=-0.5$ and 0, respectively. The source area of the 1979 Iwate-oki tsunami was located near the Japan Trench and the length was 50 km. The source area of the 1981 tsunami lay on the east side of the 1978 Miyagi-oki tsunami ($m=0.5$) and the length was 60 km in an east-west direction. These source dimensions are nearly standard for earthquakes of magnitude (M 6.5–7.0).

In the space distribution of tsunami sources during the past 85 years (1897–1981), a remarkable seismic gap can be seen in a segment of 150–200 km along the trench far off Miyagi. In the southern Sanriku region, no event has occurred for at least 85 years since the earthquake of Aug. 5, 1897 ($M=7.7$). This 1897 tsunami ($m=2$) caused much damage to houses with waves 2–3 meters high. A segment of 200 km far off Miyagi should be considered as an area of relatively high tsunami risk.

1. Introduction

As is well kown, seismicity off the Sanriku coast, northeastern Japan, is very active and many tsunamis have been generated. During the last three years since the 1978 Miyagi-oki tsunami (HATORI, 1978) one small tsunami was generated off Iwate on Feb. 20, 1979 and one off Miyagi Prefecture on Jan. 19, 1981. These tsunamis were observed by many tidal stations along the Sanriku coast. According to the analyses of the seismic and tsunami data (AIDA, 1978; SENO *et al.*, 1980; SENO and EGUCHI, 1981), the 1978 and 1981 Miyagi-oki earthquakes were caused by a low-angle thrust faulting.

In this paper, the behavior of two present tsunamis is investigated on the basis of tide-gauge records. The source areas of tsunamis are estimated by means of an inverse refraction diagram based on the arrival times of the wave front. The seismic (tsunami) gap is examined by adding the new data to the source areas of tsunamis which have

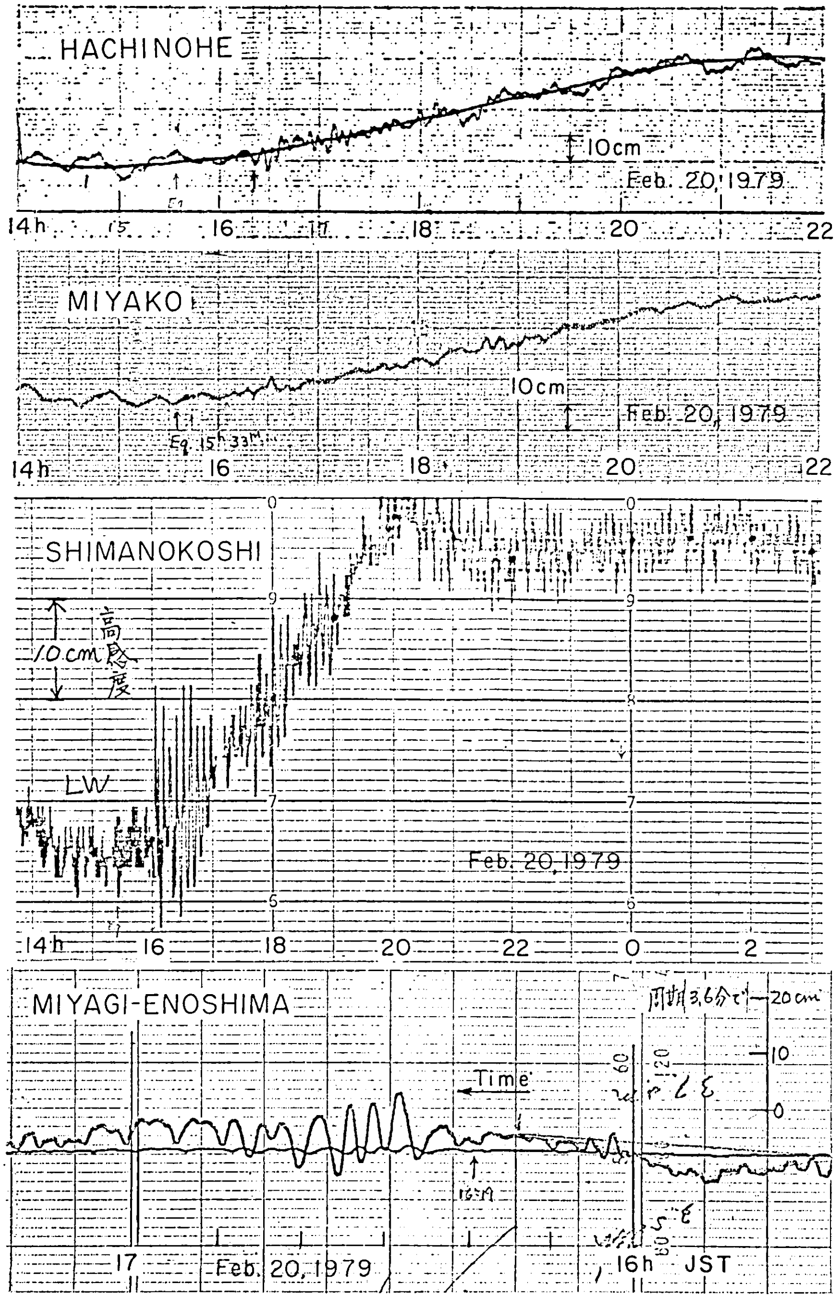

Fig. 1. Tide-gauge records of the tsunami generated off Iwate Prefecture on Feb. 20, 1979, where the records at Miyagi-Enoshima was obtained by the ERI-IV tsunami recorder.

been generated off the Sanriku coast during the past 85 years (HATORI, 1969, 1974).

2. Tsunami data

The 1st tsunami was generated far off Iwate Prefecture at 15 h 32 m (JST) on Feb. 20, 1979. According to the seismological bulletin of

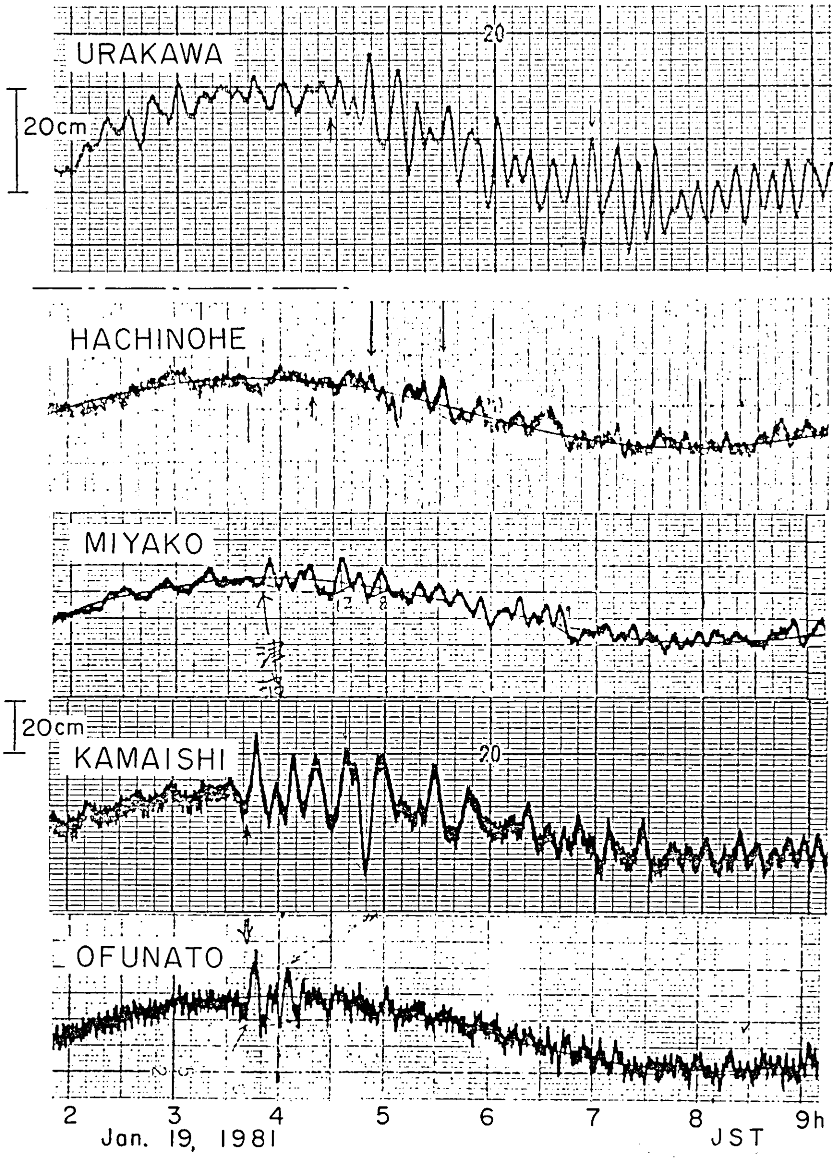

Fig. 2a. Tide-gauge records of the tsunami generated off Miyagi Prefecture on Jan. 19, 1981.

the Japan Meteorological Agency (JMA), the epicenter of the main shock was 40°13′N, 143°52′E with a depth of 0 km, the earthquake magnitude being $M=6.5$. The 2nd tsunami was generated off Miyagi Prefecture, southern Sanriku, at 3 h 17 m (JST) on Jan. 19, 1981. The epicenter of the main shock was 38°36′N, 142°58′E, the earthquake magnitude being $M=7.0$.

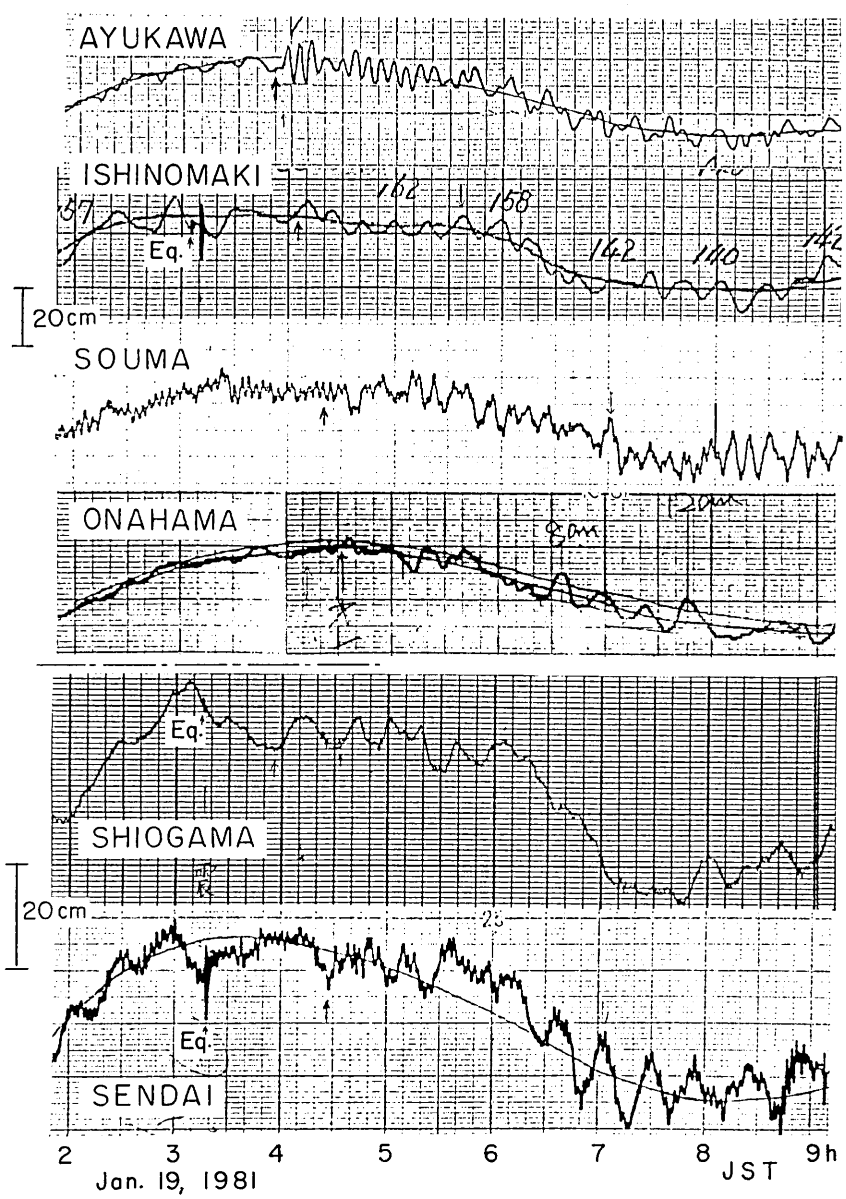

Fig. 2b. Tide-gauge records of the tsunami generated off Miyagi Prefecture on Jan. 19, 1981.

Figures 1, 2a and 2b show some tide-gauge records of the two tsunamis and their locations are shown in Figs. 5 and 6. For the tsunami on Feb. 20, 1979, a wave of relatively large amplitude with short period was locally observed at Shimanokoshi. Figure 3 shows the

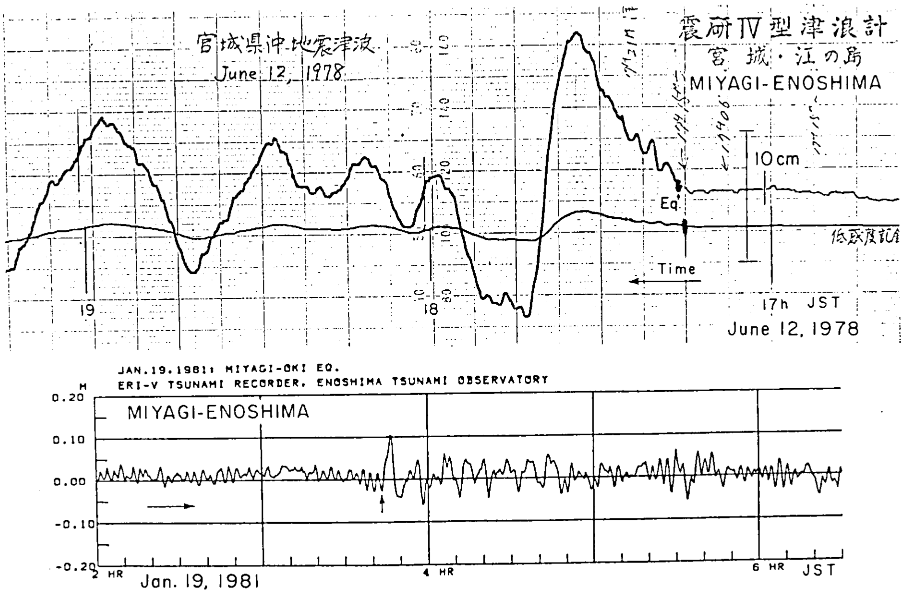

Fig. 3. Records of the Miyagi-oki tsunamis on June 12, 1978 and Jan. 19, 1981 at Miyagi-Enoshima. The records were obtained by the different tsunami recorders.

Table 1. The tsunami of Feb. 20, 1979, as recorded by tide-gauges. Wave originated near the epicenter (40°13′N, 143°52′E, $d=0$ km, $M=6.5$; JMA) off Iwate Prefecture, at 15:32 (JST), Feb. 20, 1979.

Tide station	Initial wave			Maximum wave			
	Travel time	Rise	Period	τ		Double ampl.	H
	min	cm	min	h	m	cm	cm
Hanasaki	?						
Hiroo	?					8	5
Urakawa	41	4	9	2	43	9	5
Hachinohe	48	6	7		48	10	6
Kuji	?					20	8
Shimanokoshi	30	15	9		05	24	15
Miyako	?					6	4
Ofunato (Nagasaki)	?					13	7
Enoshima	46	4	5		09	12	9
Ayukawa	52	5	8		11	13	8
Onahama	?					6	4

H: Semi-amplitude above ordinary tides. τ: Time interval between the arrival of wave front and the maximum wave crest.

Table 2. The tsunami of Jan. 19, 1981, as recorded by tide-gauges. Wave originated near the epicenter (38°36′N, 142°58′E, d=0 km, M=7.0; JMA) off Miyagi Prefecture, at 3:17 (JST), Jan. 19, 1981.

Tide station	Initial wave			Maximum wave			
	Travel time	Rise	Period	τ		Double ampl.	H
	min	cm	min	h	m	cm	cm
Hanasaki	?					7	5
Kushiro	?					8	4
Hiroo	?					12	9
Shoya						17	8
Urakawa	71?	4	8	2	30	18	12
Hachinohe	62?	3	12	1	13	13	8
Miyako	30	8	10		44	23	10
Kamaishi	26	23	11		55	37	22
Ofunato (Nagasaki)	26	20	10		05	28	20
Kesen'numa (Oura)	30	15	16		55	20	15
Tsukihama	34	22	12		05	30	22
Enoshima	25	11	9		03	14	10
Ayukawa	33	8	8		15	15	8
Ishinomaki (Industrial Port)	60	6	12	1	30	9	6
Shiogama	76?	4	19		10	6	4
Sendai (Industrial Port)	68?	4	8	2	32	15	6
Souma	60	3	12	2	40	18	12
Matsukawaura	62	2	23	2	40	11	8
Onahama	54?	3	9	3	34	14	8
Hitachi	58	4	8	2	50	16	11
Ooarai	56?	7	10	2	42	18	10
Mera	?					12	8

H: Semi-amplitude above ordinary tides. τ: Time interval between the arrival of wave front and the maximum wave crest.

records of the two Miyagi-oki tsunamis on June 12, 1978 and Jan. 19, 1981 obtained from different tsunami recorders at Miyagi-Enoshima (AIDA *et al.*, 1981). The wave period of the 1978 tsunami is 25 min, while that of the 1981 tsunami is 9 min, suggesting a small source area. Summaries of the principal features of records at various stations are given in Tables 1 and 2. The double amplitude of the 1979 tsunami is on an order of 10–20 cm with the period of 5–8 minutes. The double amplitude of the 1981 tsunami is 20–30 cm with the period of about 10 minutes.

Using the author's method (HATORI, 1979), the attenuation of tsunami height with distance from the epicenter, the tsunami magnitude of the Imamura-Iida scale, m, is determined in Fig. 4. On the average, the magnitude of the 1979 Iwate-oki tsunami is determined

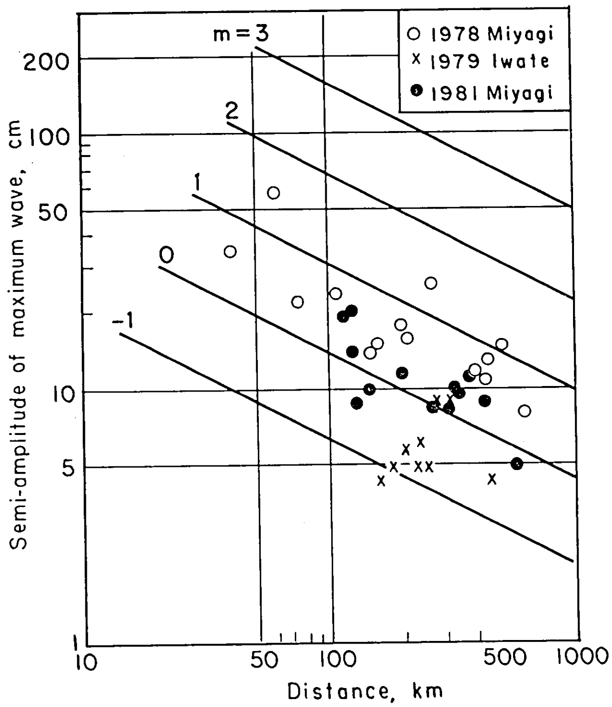

Fig. 4. Magnitude of the tsunamis generated off Iwate and Miyagi Prefectures. The straight lines are for tsunami magnitude of the Imamura-Iida scale which is classified by the attenuation of tsunami height with distance from the epicenter.

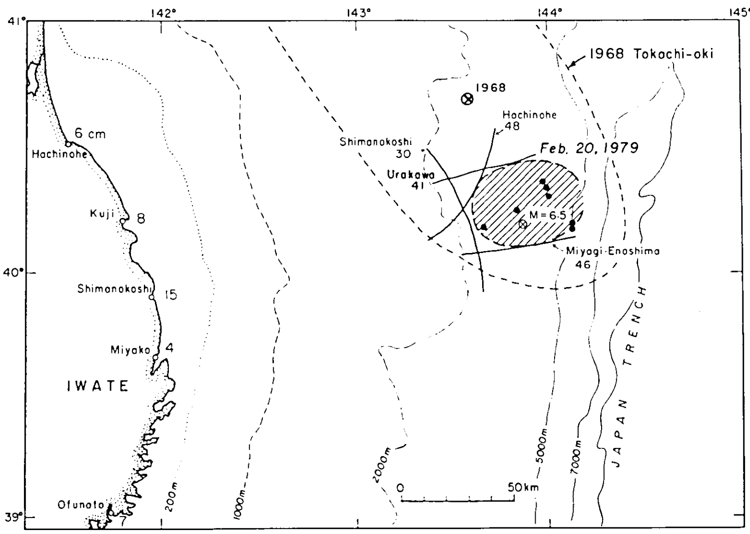

Fig. 5. Estimated source area of the Iwate-oki tsunami on Feb. 20, 1979, and distribution of aftershocks (closed circles). The last wave fronts correspond to travel times (min). The observed semi-amplitudes (unit: cm) are also shown.

to be $m=-0.5$. The magnitudes of the 1978 and 1981 Miyagi-oki tsunamis are $m=0.5$ and 0, respectively. On the statistical relation between earthquake and tsunami, the magnitude of the 1978 tsunami was relatively small compared to the earthquake magnitude ($M=7.4$), and that of the 1981 tsunami was average.

3. Source area of tsunami

Figure 5 shows the source area of the 1979 tsunami inferred from an inverse refraction diagram. The estimated source area was located in the southern part of the 1968 Tokachi-oki tsunami source ($m=2.5$). The length of the tsunami source is about 50 km and the area is 1.6×10^3 km^2.

Figure 6 shows the estimated source area of the 1978 Miyagi-oki (HATORI, 1978) and the 1981 tsunamis. Although the source area of the 1978 tsunami was located on the shallow sea extending 100 km in a N-S direction, that of the 1981 tsunami lay on the east side of the

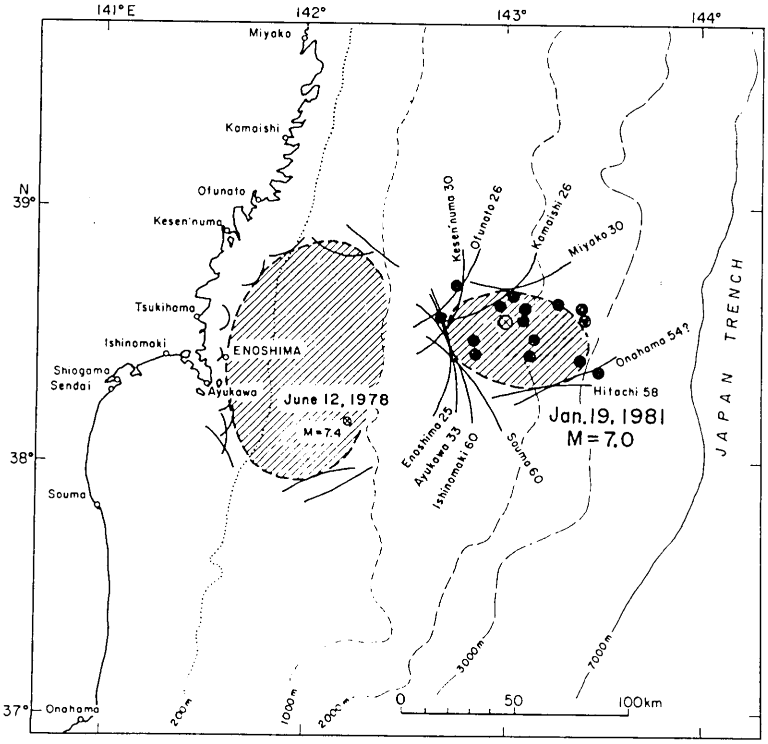

Fig. 6. Estimated source areas of the Miyagi-oki tsunamis on June 12, 1978 and Jan. 19, 1981. The last wave fronts correspond to travel times (min). Closed circles indicate aftershocks of the 1981 earthquake.

1978 tsunami source between the 1,500 and 3,000 m contour lines. The length of the 1981 tsunami source is 60 km and the area is 1.9×10^3 km^2. The estimated source areas of the 1979 and 1981 tsunamis agree well with the aftershock distributions determined by the JMA and the microseismic network of the Tohoku University (1981). The sea-bottoms of these regions seem to be the upheaval, because the initial motion of tsunamis was observed with an upward direction at every tidal station.

4. Tsunami sources in northeastern Japan

All the estimated source areas of tsunamis generated in northeastern Japan during the past 85 years (1897–1981) are shown in Fig. 7, where the figure on the left shows the tsunamis generated before the large Sanriku tsunami of 1933 while that on the right shows those there after. The tsunami magnitudes of the Imamura-Iida scale are shown in parentheses.

Off Miyagi, it is seen the tsunami generating region moves in an eastward direction. Some seismologists (*e.g.*, SENO, 1979 a, b) suggest the possibility of a large earthquake off the southern Sanriku coast in the near future on the basis of the seismic activity. Figure 7, obtained from the tsunami data (HATORI, 1974), shows that a remarkable

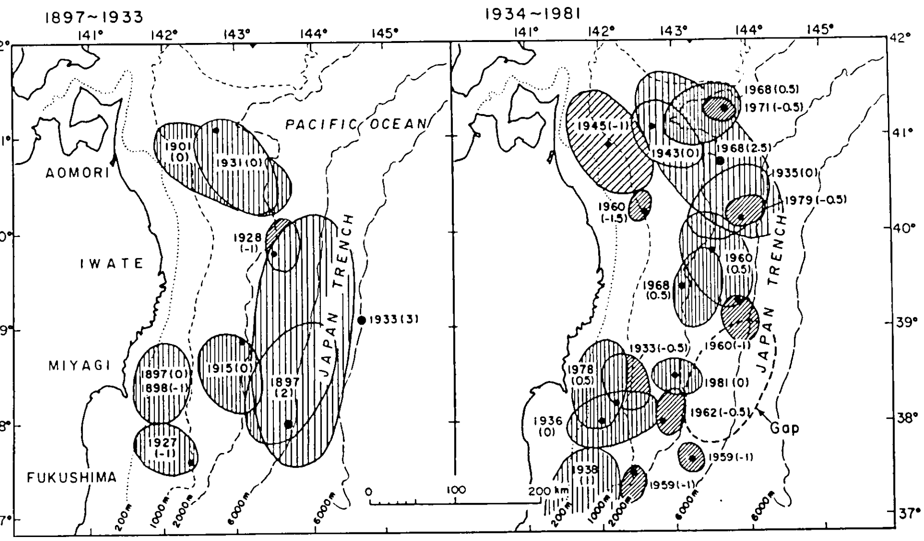

Fig. 7. Distribution of the estimated source areas of tsunamis generated off the Sanriku coast during the past 85 years (1897–1981). Dates and the tsunami magnitude of Imamura-Iida scale, *m*, are indicated. Left and right figures show the tsunamis before and after the 1933 large Sanriku tsunami.

tsunami (seismic) gap exists near the trench, where no event has occurred during the 85 years since the earthquake on Aug. 5, 1897 (M=7.7). The source area of this tsunami lay on the steep continental slope and extended 150 km parallel to the Japan Trench.

From the reports of the 1897 tsunami (ANONYMOUS, 1897; IMAMURA, 1899), inundation heights along the Sanriku coast are shown in Fig. 8. The inundation heights were 2–3 meters. The tsunami overflowed on land at 2 meters high and many houses were inundated on floors at 2.5 meters or more. For example, 57 houses at Onagawa and 125 houses between Shizukawa and Onagawa, Miyagi Prefecture, were inundated by waves 2.5–3 meters high. At the Ayukawa tidal station, the initial wave was seen to have a downward motion (Fig. 8), while that of the 1933 Sanriku tsunami was recorded with upward motion (HATORI, 1974). It suggests the differences of the source mechanism and fault plane of the two earthquakes.

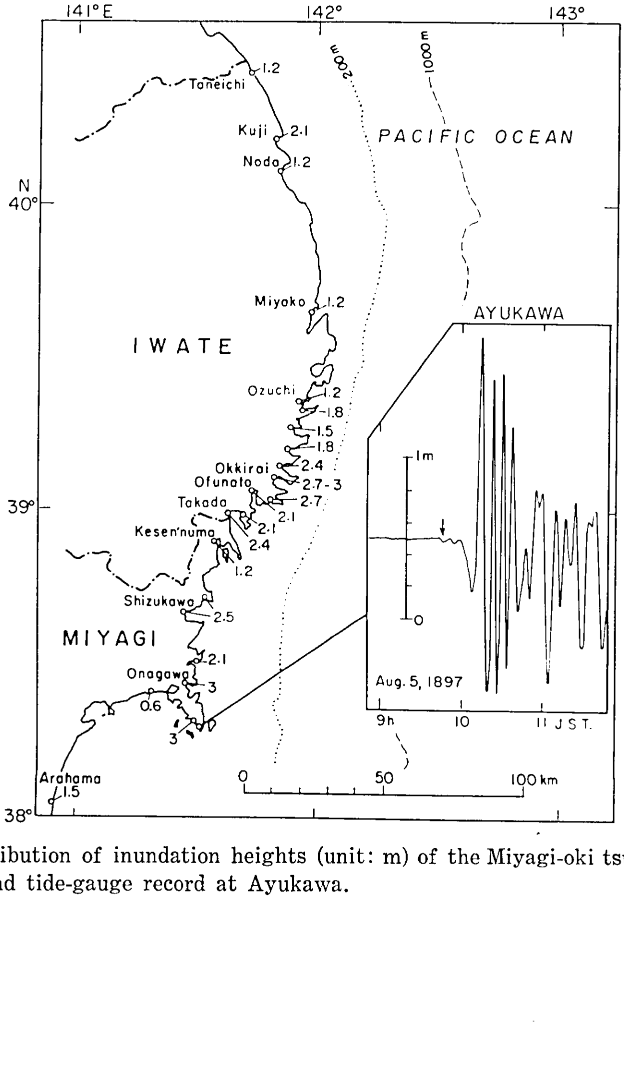

Fig. 8. Distribution of inundation heights (unit: m) of the Miyagi-oki tsunami on Aug. 5, 1897 and tide-gauge record at Ayukawa.

5. Conclusion

Based on the tide-gauge records, the magnitudes and source areas for the Iwate-Miyagi tsunamis in 1979 and 1981 were investigated. Adding the present data, all the estimated source areas of the tsunamis generated off the Sanriku coast in the past 85 years are shown on a bathymetric chart.

The behavior in the space-time of tsunami activity in the Sanriku region suggests that the area off Miyagi near the Japan Trench may be considered a region of relatively high tsunami risk with the magnitude of $m=2$. There is another remarkable region off Aomori Prefecture, northern Sanriku. The occurrence of the 1901 Hachinohe-oki earthquake ($M=7.7$–7.8) will be repeated in the near future. The expectant tsunami effect is small, but the seismic intensity may be strong along the coast.

Acknowledgment

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References

AIDA, I., 1978, Numerical experiments for the tsunami accompanying the Miyagi-oki earthquake of 1978, *Bull. Earthq. Res. Inst.*, **53**, 1167–1175 (in Japanese).

AIDA, I., DATE, D., SAKASHITA, S., and M. KOYAMA, 1981, The new tsunami recorders (ERI-V) at the Enoshima and the Izu-Oshima tsunami observatories, *Bull. Earthq. Res. Inst.*, **56**, 571–585 (in Japanese).

ANONYMOUS, 1897, Note on the Miyagi-oki tsunami of Aug. 5, 1897, *J. Geography*, **9** (104), p. 391 (in Japanese).

HATORI, T., 1969, Dimensions and geographic distribution of tsunami sources near Japan, *Bull. Earthq. Res. Inst.*, **47**, 185–214.

HATORI, T., 1974, Tsunami sources on the Pacific side in Northeast Japan, *Zisin*, **27**, 231–337 (in Japanese).

HATORI, T., 1978, The tsunami generated off Miyagi Prefecture in 1978 and tsunami activity in the region, *Bull. Earthq. Res. Inst.*, **53**, 1177–1189 (in Japanese).

HATORI, T., 1979, Relation between tsunami magnitude and wave energy, *Bull. Earthq. Res. Inst.*, **54**, 531–541 (in Japanese).

IMAMURA, A., 1899, Investigation of the Sanriku tsunamis, *Ret. Imp. Earthq. Inv. Comm.*, **29**, 17–32 (in Japanese).

SENO, T., 1979a, Intraplate seismicity in Tohoku and Hokkaido and large interplate earthquakes: A possibility of a large interplate earthquake off the southern Sanriku coast, Northern Japan, *J. Phys. Earth*, **27**, 21–51.

SENO, T., 1979b, On the earthquake expected off Miyagi Prefecture, *Rep. Coord. Comm. Earthquake Predict.*, **21**, 38–43 (in Japanese).

SENO, T., SHIMAZAKI, K., SOMERVILE, P., and K. SUDO, 1980, Rupture process of the Miyagi-oki, Japan, earthquake of June 12, 1978, *Phys. Earth Planet. Inter.*, **23**, 39-61.

SENO, T. and T. EGUCHI, 1981, Focal mechanism of the Miyagi-oki earthquake of Jan. 18, 1981 and its geographic signification, *Abstract, Annual Meeting of Seism. Soc. of Japan*, No. 2, p. 7 (in Japanese).

TOHOKU UNIV., Faculty of Science, 1981, Microseismic activity in and near the Tohoku district (Nov. 1980-Apr. 1981), *Rep. Coord. Comm. Earthquake Predict.*, **26**, 18-29 (in Japanese).

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31. 1979年岩手・1981年宮城沖津波の波源——宮城沖の地震空白域

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1978年宮城県沖地震後，この3年間に岩手と宮城県沖に2個の小津波が発生し，本所の江ノ島津波観測所をはじめ沿岸各地の検潮所で観測された．津波の概況は次の通りである．

1)　1979年2月20日の岩手沖津波

岩手県はるか沖合の海溝付近の地震(M=6.5)に伴った津波である．岩手・宮城沿岸で全振幅10～20 cm，周期5～8分の波が記録された．筆者の方法によれば，津波の規模（今村・飯田スケール，m）は $m=-0.5$ と判定される．津波の逆伝播図から，推定波源域の長さは 50 km，面積 1.6×10^3 km^2 であった．

2)　1981年1月19日の宮城沖津波

1978年宮城県沖地震より沖合におきた地震（M=7.0）によるもので，宮城・岩手沿岸で津波の全振幅 20～30 cm，周期は10分前後であった．津波の規模は $m=0$ と格付けされ，1978年津波（m=0.5）のエネルギーの約1/2である．推定波源域は東西方向に伸び，長さ 60 km，面積にして 1.9×10^3 km^2 である．

両波源域ともほぼ余震域と合致しており，津波初動がいずれもみな押し波で記録され，その振幅の大きさから，波源域の海底が10数cm隆起したことを考えさせる．また，地震規模に比べ，1979年津波の規模はやや大きく，1981年津波は標準的であったといえる．

これらの津波データを加え，最近85年間における三陸沖の波源域分布をみると，宮城県はるか沖合の海溝ぞい 150 km の区間が地震の空白域として，目立ってきた．この海域は1897年8月に，中規模の津波（m=2）がおきたところである．この津波は，宮城県桃生・牡鹿郡の沿岸に 2～3 m の波高を記録し，200戸ほどに浸水被害を与えた．それからすでに85年が経過し，1897年津波の発生域が，その周辺の津波活動からみて，再発の可能性の高い海域と考えられる．