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302/MB/87/06/11

JUN 11 1987

Mr. Paul Whitmore
U.S. National Weather Service
Alaska Tsunami Warning Center
910 South Felton Street
Palmer, AK 99645

Dear Mr. Whitmore:

Thank you for your inquiry regarding my presentation at the 1986 Fall Meeting of the American Geophysical Union. Unfortunately the priorities and workload associated with my position here at the Nuclear Regulatory Commission have left precious little time to prepare a journal-quality article on the report. I am enclosing a short note on the Andeanof Islands tsunami that I prepared for internal distribution to members of the Commission staff concerned with nuclear power plant safety. This note was written shortly after the event and it includes many of the points I discussed in my presentation. I am also including for your information a copy of the abstract for my forthcoming presentation at the IUGG in Vancouver this summer. If I can be of further assistance to you in this project, please do not hesitate to ask.

Sincerely,

/S/

Michael E. Blackford
Project Manager Seismologist
Geology/Geophysics Section
Technical Review Branch
Division of Waste Management

Enclosures:
As stated

NOTE ON THE TSUNAMI CAUSED BY THE ANDREANOF ISLANDS, ALASKA EARTHQUAKE OF MAY 7, 1986

by Michael E. Blackford

INTRODUCTION

The purpose of this note is to review the observed water-level gauge heights resulting from the tsunami generated by the Andreanof Islands, Alaska earthquake of May 7, 1986 in the light of the tsunami magnitude scale proposed by Abe in 1979. The earthquake occurred in the central Aleutian Islands of Alaska and caused damage on both Atka and Adak Islands at distances of about 100 and 150 kilometers from the epicenter respectively. An ocean-wide tsunami was generated by the earthquake with a maximum recorded gauge height at Adak of 175 centimeters and recordings throughout the Pacific Basin to stations as far away as New Zealand and Chile.

I shall first consider the earthquake itself, its size and its possible mechanism. Using the reported water-level gauge heights for Honolulu, Hilo, California, and Japan, I shall then determine earthquake parameters using relationships developed by Abe for his study of several nineteenth century Pacific Basin earthquakes. Finally I shall discuss causes for the apparent discrepancies between size of the earthquake determined by methods based on seismic instruments and by the Abe method.

THE MAY 7, 1986 ANDREANOF ISLANDS EARTHQUAKE

The May 7, 1986 Andreanof Islands earthquake occurred at 224710.2 GCT (PDE 19-86) and was centered at 51.4°N and 174.8°W. The Ms magnitude of the earthquake, listed in PDE 19-86, is 7.7. Robert Urhammer of the University of California Seismograph Stations (personal communication, May, 1986) reports the earthquake to have a moment, M_0, of 7×10^{27} dyne-centimeters which yields a moment magnitude, Mw, of 7.8 where $Mw=2/3(\log M_0 - 16.1)$ (Kanamori, 1977). Using the relationship of Kanamori and Anderson (1975), $Mw=\log(S)+4$, where S is the area, in square kilometers, of the first day's aftershocks, Mw is 7.8. Figure 1 illustrates this area superimposed on a National Earthquake Information Service plot of the aftershocks through May 23, 1986 (PDE 18-86). The dashed line represents the perimeter of an area of 6636 square kilometers containing the aftershocks occurring between 2247 GCT, May 7, 1986 and 2247 GCT, May 8, 1986. A rectangular area of equivalent size, drawn parallel to the trend of the active volcanic arc, the long-dashed line north of the rectangle,

is also shown. The long dimension of this rectangle may represent the strike of the causative fault for this earthquake. The earthquake and its aftershock sequence appear to define an episode of subduction of the Pacific plate beneath the North American plate and the coseismic deformation of the Pacific plate leading to the generation of the ocean-wide tsunami.

MAGNITUDE DETERMINATION BY THE ABE METHOD

According to PDE 19-86, the following maximum wave heights were recorded: at Hilo, Hawaii, 55 cm.; at Honolulu, Hawaii, 27 cm.; at Kushiro, Japan, 46 cm.; at Crescent City, California, 12 cm.; and at San Francisco, California, no recorded tsunami. The average gauge height for California is taken here to be 6 cm. It is assumed that these gauge heights represent crest-to-trough heights. By the Abe method the moment magnitude of an earthquake may be determined by the relationship Mw=Mt=logH+B, where Mt is Abe's tsunami magnitude, H is one-half the crest-to-trough height in meters, and B is a factor, dependent upon the source-to-station path, which makes the Abe magnitude equivalent to the moment magnitude. The moment magnitude determination can be tabulated as follows:

	Ho	Hi	Ca	Ja
H, one-half crest-to-trough height:	0.135	0.275	0.03	0.23
B, Aleutian-Alaska source from Abe:	9.6*	9.1	9.3	9.4
Mw, equivalent to Abe's Mt:	8.7	8.5	7.8	8.8

* the B-factor given in the Abe paper for the Aleutian-Alaska/Honolulu source-station pair for the 1965 Aleutian earthquake is in error; thus the average B-factor is 9.6 rather than 9.2

It is readily seen that the Abe method, except for the California, yields moment magntudes that are too high relative to the moment magnitude determined by other methods. The average moment magnitude based on these data is 8.5.

The data used by Abe to determine B-factors for Honolulu, Hilo, California, and Japan are presented here together with the data for the May 7, 1986 earthquake:

			Ho		Hi		Ca		Ja	
Date	Source	Mw	H	B	H	B	H	B	H	B
3/28/64	Alaska	9.2	0.5	9.5	2.1	8.9	0.83	9.3	0.36	9.6
2/ 4/65	Aleutian	8.7	0.1	9.7*	0.3	9.2	--	--	0.31	9.2
5/ 7/86	Aleutian	7.8	0.135	8.7	0.275	8.4	0.03	9.3	0.23	8.4
	Revised average B-values:			9.3		8.8		9.3		9.1

* the B-factor given in the Abe paper, 8.8, is in error; the correct value, using the expression B=Mw-logH, is 9.7

Using the revised average B-factors, the moment magnitudes are 8.4, 8.2, and 8.5 for Honolulu, Hilo, and Japan respectively. These values are still high but they are closer to the moment magnitude determined for the earthquake at this time.

Calculated water-levels for Honolulu, Hilo, California, and Japan can be determined by inverting the Abe relationship such that logH=Mw-B. The water-level, crest-to-trough, is double the value of H. The calculated water-levels are 6 cm. at Honolulu, 20 cm. at Hilo, 6 cm. for California, and 10 cm. for Japan. The observed values are approximately four times higher than the calculated values.

DISCUSSION

A number of factors may be contributing to the discrepancy between the moment magnitude determination by the Abe method and by the other methods. First the B-factors are based on a paucity of data, only the 1964 Alaska Earthquake and the 1965 Rat Island Earthquake, and may need to be revised. Second, the mechanism of the earthquake which, according to the work of Ward (1982), can affect the relationship between the seismic surface waves and the tsunami amplitudes by nearly an order of magnitude has not yet been determined with any precision. Third, there is no directivity factor in the Abe method. And finally, the observations for Japan and California should include more tide station data in order to have a more representative average observation.

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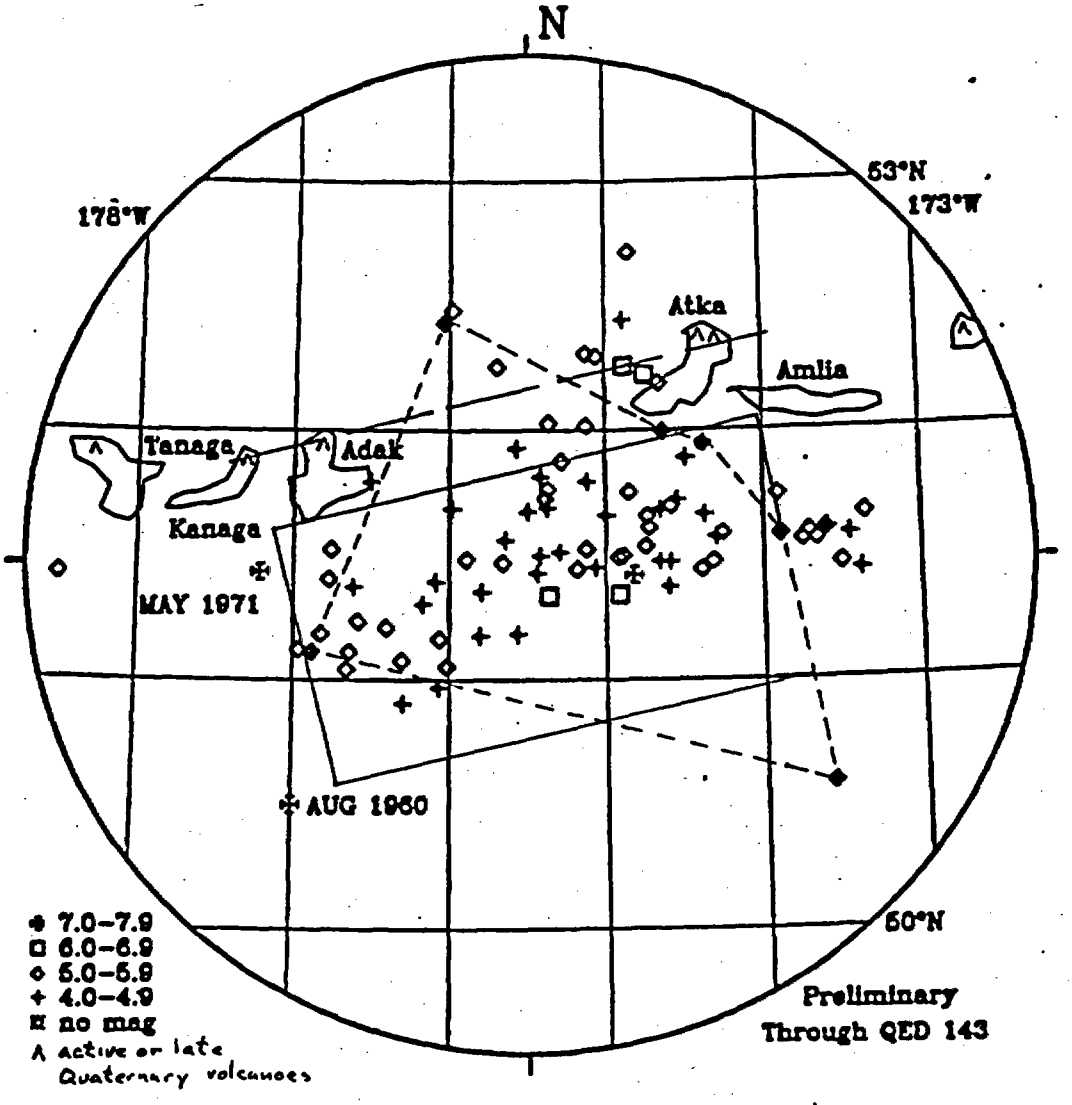
Andreanof Islands, Aleutian Is.
Earthquake Series
May 1986



STATISTICAL RELATIONSHIPS BETWEEN EARTHQUAKE MOMENT MAGNITUDE AND WATER-LEVEL GAUGE HEIGHTS FOR PACIFIC BASIN TSUNAMIS

Blackford, M.E., U.S. Nuclear Regulatory Commission, Mail Stop 623-SS, Washington, DC 20555

The generation of most ocean-wide tsunamis in the Pacific Basin can be attributed to the occurrence of large to great earthquakes associated with the process of subduction of tectonic plates in the northwestern Pacific, along the Alaska-Aleutian margin, and off of South America. Recent improvements in seismic instrumentation have made the timely determination of the rupture process, and its extent, a real possibility. Based on this information, the height of a potential tsunami, as recorded on water-level gauges, can be estimated for regions outside of the immediate vicinity of the causitive earthquake. Relationships between moment magnitudes, derived from rupture process analyses, and the maximum tsunamis observed on selected sets of water-level gauges are summarized in the following table:

Source/Impact Region Coefficients for
$\log H = -a + b * Mw$

	JAPAN		ALASKA		CALIF.		HONOLULU		HILO	
	a	b	a	b	a	b	a	b	a	b
NW			7.26	0.80	9.32	1.01	7.68	0.82	10.15	1.17
AK	3.77	0.39			7.89	0.83	5.09	0.51	7.58	0.86
SA	8.20	0.90	6.33	0.97			6.30	0.66	8.75	1.04

where H is maximum gauge height in meters, Mw is the moment magnitude, and NW, AK, and SA represent the northwestern Pacific, Aleutian-Alaska, and South America source regions respectively. The primary sources of error in these data are uncertainties associated with the reporting of the tsunami heights and the determination of the rupture process. These relationships, coupled with appropriately conservative margins of safety, could be used to test the possibility of forecasting tsunami heights for the impact regions listed.

OFFICIAL CONCURRENCE AND DISTRIBUTION RECORD

LETTER TO: Mr. Paul Whitmore
U.S. National Weather Service
Alaska Tsunami Warning Center
910 South Felton Street
Palmer, AK 99645

FROM: Michael E. Blackford
Project Manager Seismologist
Geology/Geophysics Section
Technical Review Branch
Division of Waste Management

SUBJECT: REPORT ON 1986 ANDREANOF ISLANDS EARTHQUAKE TSUNAMI

DATE: JUN 11 1987

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