

UNCLASSIFIED

AD NUMBER
AD840477
NEW LIMITATION CHANGE
TO Approved for public release, distribution unlimited
FROM Distribution authorized to U.S. Gov't. agencies and their contractors; Critical Technology; AUG 1968. Other requests shall be referred to Naval Oceanographic Office, Attn: Code 40, Washington, DC 20390.
AUTHORITY
USNOO Notice, 25 Jan 1972

THIS PAGE IS UNCLASSIFIED

AD840477

IR NO. 68-61

INFORMAL REPORT

EARTHQUAKES, TSUNAMIS, AND
VOLCANOES IN THE
NORTHEASTERN INDIAN OCEAN

AUGUST 1968

D D C
RECEIVED
OCT 3 1968
RECEIVED
C

The opinions and assertions contained in this report are solely those of the author(s) and should not be taken as an official or inferred official opinion of the Naval Oceanographic Office, Department of the Navy, Department of Defense, or United States Government.

STATEMENT 2 UNCLASSIFIED

This document is subject to special export controls and each transmittal to foreign governments or foreign nationals may be made only with prior approval of _____

NAVAL OCEANOGRAPHIC OFFICE

WASHINGTON, D. C. 20390

Code-40

ABSTRACT

This paper gives information on earthquakes, tsunamis and volcanoes in the Northeastern Indian Ocean and adjacent land areas. Most of the seismic activity in this region has occurred along the Burma-Sunda arcs, the 89th meridian between 5°N. and 5°S., and southwest of Ceylon. For the most part earthquake damage and destruction have been limited to a zone stretching from Sumatra to the Ganges Delta.

Tsunamis and other large waves have been reported from most coastal sectors in the area. Damage by tsunamis has been restricted to the coasts of Sumatra and adjacent islands. Destructive storm-generated waves have been reported from the northern shores of the Bay of Bengal.

Active volcanoes in the area are located on Sumatra and Barren Island. A submarine eruption was reported on the flank of the Ninety East Ridge in 1883. Mud volcanoes have been reported from the coast of Burma and off the southwest coast of India.

This Informal Report was prepared by:
Geology Section
Environment Branch
Oceanographic Analysis Division

This manuscript has been reviewed
and is approved for release as an
UNCLASSIFIED Informal Report.

R. M. Holcombe (Act)
A. R. GORDON, JR.
Division Director

CONTENTS

	Page
Abstract	1
A. Earthquakes	1
B. Tsunamis	5
C. Volcanism	9
References	11

FIGURES

1. Earthquake epicenters and volcanoes	2
2. Regions affected by seismic activity	4

A. Earthquakes

Most seismic activity in this area is confined to three zones: one along the Burma-Sunda arcs, one paralleling the 89th meridian between 5°N. and 5°S. , and one southwest of Ceylon. The epicentral location of representative strong shocks (Classes A and B) and many weaker shocks (Classes C and D) that have occurred in and near the area are shown in Figure 1 .

The Burma-Sunda arcs are the link between the Circum-Pacific and Alpine seismic belts. Most of the shocks in the Burma-Sunda arcs occurred at shallow depths (less than 60 km.), although many shocks of intermediate depth (70 to 300 km.) are reported from Sumatra and northern Burma. A few shocks of intermediate depth have been reported east of the Andaman Islands. The concentration of shallow and intermediate shocks in the vicinity of 25°N. , 95°E. is at the intersection of two structural arcs. The relatively infrequent shallow shocks between the Andaman Islands and Burma, coupled with the absence of intermediate depth shocks, may indicate a break in the Burma-Sunda

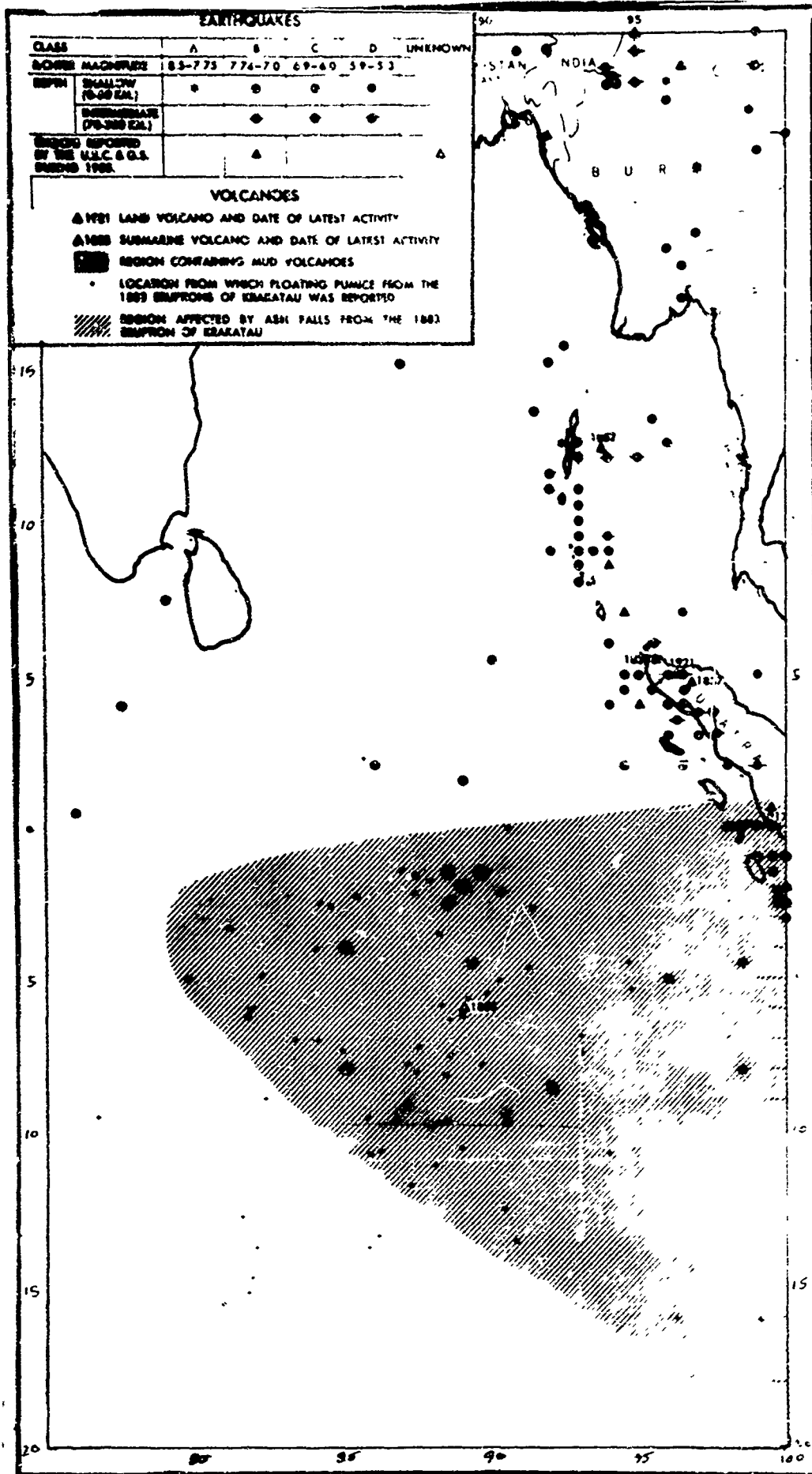


Figure 1 Earthquake epicenters and volcanoes

structural trend.

Recent bathymetric surveys tend to confirm the prediction made on seismic evidence as early as 1949 that the zone of seismic activity which parallels the 89th meridian coincides with a structural ridge. The minor seismic region which extends southwest from Ceylon may mark a similar structural feature.

Regions which have been affected by seismic activity (Figure 2) generally coincide with the location of earthquake epicenters (Figure 1). The most destructive earthquakes have occurred in a zone stretching from Sumatra through the Nicobar and Andaman Islands into southwestern Burma and the Ganges Delta. The destruction caused by earthquakes in this region results from strong shocks, which occur frequently, or from the unstable foundation characteristics of the alluvial soil of the Ganges and Irrawaddy Deltas, which lie adjacent to the regions of frequent shocks. Building damage in southern India probably was caused by small local shallow earthquakes which were not associated with major tectonic movements.

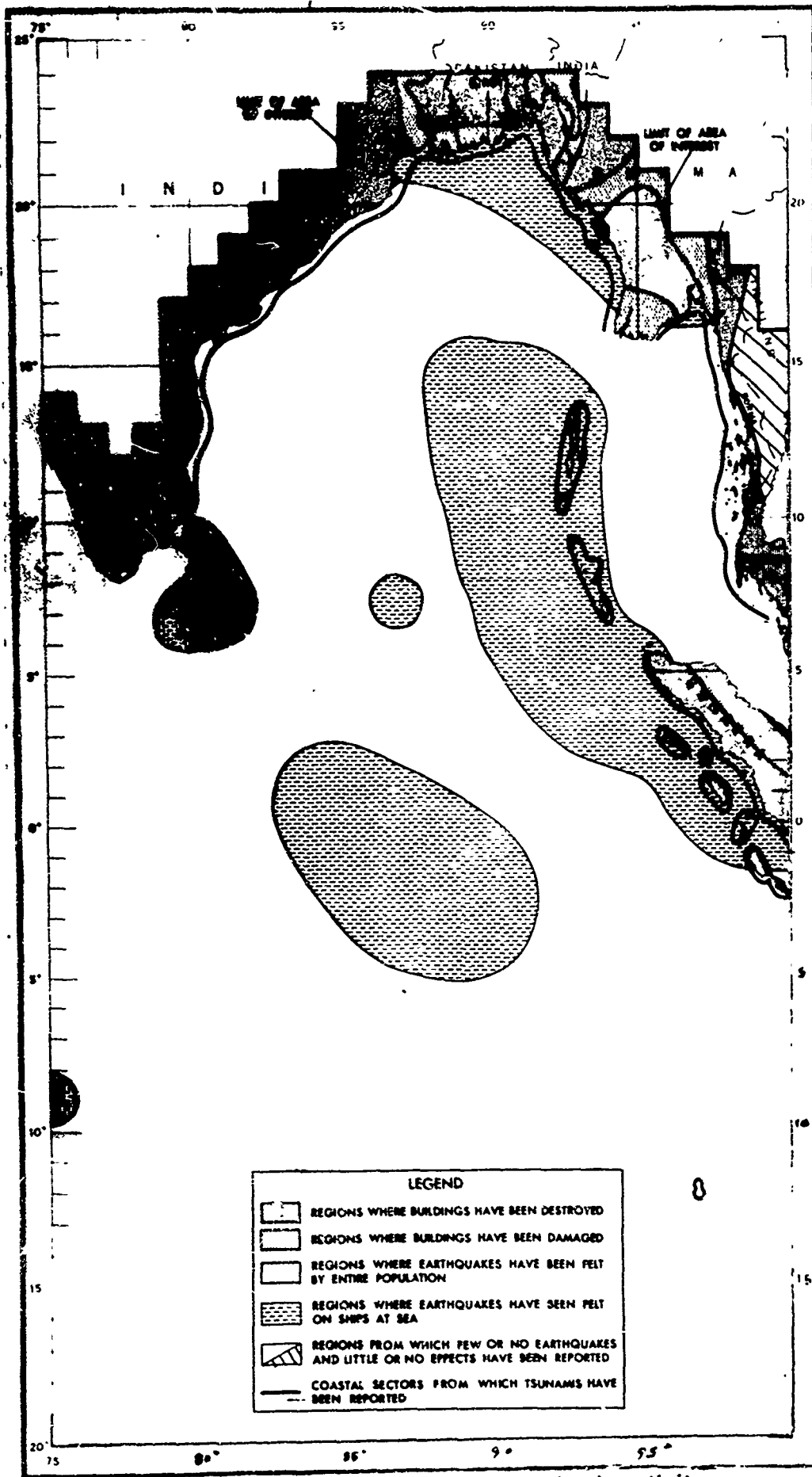


Figure 2 Regions affected by seismic activity

One of the largest earthquakes recorded anywhere in the world occurred in Assam (26°N. , 93°E.) in 1897 (epicenter 26°N. , 91°E.). Another very large earthquake occurred at 29°N. , 97°E. in 1950. Both of these shocks were felt over a large part of India, Pakistan, and Burma. The 1897 shock was felt over a region of 1,750,000 square miles. Buildings in a region of 150,000 square miles suffered moderate damage; buildings in a region of about 9,000 square miles were completely destroyed.

Earthquakes have been reported from ships at sea at several places in the area. The distribution of these reports depends upon the positions of ships at the time of the earthquake relative to the epicentral location.

B. Tsunamis

Eighteen tsunamis were reported from this area between 1762 and 1909. Six of these occurred in the Bay of Bengal, and 12 struck the west coast of Sumatra and neighboring islands (Figure 2). The tsunami generated by the explosive eruption of Krakatau in 1883 was reported in these regions as well as in the Cocos-Keeling Islands.

In addition to tsunamis, seismic seiches have been generated in the distributaries of the Ganges River by most of the large earthquakes that have occurred north and east of the Ganges Delta.

In the past, damaging tsunamis have been restricted to the coast of Sumatra and adjacent islands. Other destructive waves have been generated by tropical storms. The Ganges Delta has been particularly subject to destructive storm waves and surges. In October 1960, 14,000 persons in the delta were killed or swept out to sea by the storm surges of tropical cyclones.

It is probable that more tsunamis have occurred in the past than are listed in the fragmentary reports available. Dates of occurrence and brief descriptions of tsunamis in this area follow:

1762 April 12. Earthquake felt most severely near the northern end of the Bay of Bengal. Waves reported in the distributaries of the Ganges Delta at Dacca and Calcutta and from Cheduba Island.

1797 February 10. West-central Sumatra. Waves of great force inundated the coast.

1799 West-central Sumatra. Waves about 50 feet above usual water level

reported.

1833 January 29. West-central Sumatra. Large waves destroyed a breakwater and tore ships from their anchors.

1842 November 11. Earthquake near north end of the Bay of Bengal. The waters of the distributaries of the delta were agitated.

1843 January 5 and 6. Sumatra. Earthquake and tsunami reported from the village of Barus and Pulau Nias.

1847 October 31. Little Nicobar. Kondul Island was inundated.

1861 February 16. Sumatra. Large destructive waves reported along the south coast of Pulau Nias. The Pulau Pulau Batu were inundated. Minor damage reported on other islands. Waves were noted by ships at sea.

1861 March 9. West-central Sumatra. High waves swept inland with loss of life.

1861 September 25. West-central Sumatra. High waves swept the coast.

1864 --- ---. Sumatra. Waves were reported from the Pulau Pulau Batu islands and adjacent sectors of the Sumatra coast.

- 1881 December 31. Epicenter near center of Bay of Bengal. waves were reported from Ceylon northward along the west shore of the bay to the Ganges Delta, along the Andaman and Nicobar Islands as far south as Sumatra. No waves were reported from the Burma coast.
- 1882 January or February. Ceylon. Earthquake and waves reported from Trincomalee.
- 1883 August 27. The explosive eruption of Kraukatau ($6^{\circ}10'S.$, $105^{\circ}26'E.$) in Sunda Strait ($6^{\circ}00'S.$, $105^{\circ}45'E.$) generated waves up to 100 feet high. Four-foot waves reported from the Cocos-Keeling Islands and the southwest coast of Ceylon. Waves two to three feet high reported from the east coast of India, the Ganges Delta, and the Andaman Islands.
- 1904 --- ---. Sumatra. Large waves reported from Pulau Nias. Some destruction reported from Pulau Wunga and other nearby islands.
- 1907 January. Sumatra. Earthquake and wave reported from the west coast.
- 1908 February 6. Sumatra Epicenter $5^{\circ}S.$, $100^{\circ}E.$ Earthquake and

waves reported from the south and middle parts of the west coast of the island.

C. Volcanism

Five land volcanoes and one submarine volcano have been reported active in the area during historic times (Figure 1). Active land volcanoes are located on Sumatra and Barren Island. A submarine volcanic eruption was reported in 1883 at about 6°S., 89°E. on the flank of the Ninety East Ridge.

A number of "mud volcanoes" are located off the coast of Burma near Cheduba Island and Rangoon and off the southwest coast of India near Alleppey. They are not true volcanoes but mounds of mud or mud-sand resembling bubbles which are pushed up by the expansion of gases. Since "mud volcanoes" appear suddenly, they may constitute dangers to navigation. The gases may ignite and be mistaken for a burning ship or a beacon.

The 1883 eruption of Krakatau to the east of the area was one of the world's largest explosions. It has been estimated that 5 cubic

miles of material were blown out of the volcano. The reported locations where appreciable amounts of ash and pumice fell within the area are shown in Figure 1 .

Although many other active volcanoes are located east of the area in Indonesia, no significant ashfalls from eruptions other than from Krakatau have been reported.

REFERENCES

1. SIEBERG, A. "Erdbedengeographie" (Earthquake geography).
In: Gutenberg, Beno, ed., Handbuch der Geophysik, bd. 4,
lief. 3, abschnitt 6, fig. 443, p. 820, Fig. 448, p. 833.
Berlin: Borntraeger. 1932.
2. U. S., NAVAL OCEANOGRAPHIC OFFICE. "Earthquake data and
bibliography file." Unpublished
3. ----- . "Tsunami data and bibliography file." Unpublished.
4. ----- . "Vclcano data and bibliography file." Unpublished.

Unclassified

Security Classification

DOCUMENT CONTROL DATA - R & D

(Title, location of title body of abstract and indexing annotation must be entered when the overall report is classified)

1. AUTHOR (Last name, first name, middle initial, last name) Naval Oceanographic Office		2a. REPORT SECURITY CLASSIFICATION Unclassified	
3. REPORT TITLE EARTHQUAKES, TSUNAMIS, AND VOLCANOES IN THE NORTHEASTERN INDIAN OCEAN			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Informal Report (IR No. 68-61)			
5. ACTING OFFICER (First name, middle initial, last name) Geology Section, Environment Branch			
6. REPORT DATE August 1968		7a. TOTAL NO OF PAGES 13	7b. NO OF REFS 4
8a. CONTRACT OR GRANT NO none		9a. ORIGINATOR'S REPORT NUMBER(S) IR No. 68-61	
b. PROJECT NO none		9b. OTHER REPORT NO(S) (Any other numbers that may be assigned this report) None	
c.		d.	
10. DISTRIBUTION STATEMENT U.S. Government agencies may obtain copies of this report directly from DDC. Other DDC users shall request through: Commander, Naval Oceanographic Office, Washington, D.C. 20390, ATTN: Code 40.			
11. SUPPLEMENTARY NOTES none		12. SPONSORING MILITARY ACTIVITY Naval Oceanographic Office	
13. ABSTRACT This report gives information on earthquakes, tsunamis and volcanoes in the Northeastern Indian Ocean and adjacent land areas. Most of the seismic activity in this region has occurred along the Burma-Sunda arcs, the 89th meridian between 5°N. and 5°S., and southwest of Ceylon. Tsunamis and other large waves have been reported from most coastal sectors in the area. Damage by tsunamis has been restricted to the coasts of Sumatra and adjacent islands. Active volcanoes in the area are located on Sumatra and Barren Island. A submarine eruption was reported on the flank of the Ninety East Ridge in 1683. Mud volcanoes have been reported from the coast of Burma and off the southwest coast of India. (

DD FORM 1473 (PAGE 1)
1 NOV 62

S/N 0101-807-6801

Unclassified

Security Classification

Unclassified

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Earthquakes Tsunamis Volcanoes Northeastern Indian Ocean Burma-Sunda arcs Sumatra						

Unclassified

Security Classification