

Cowasjee Earthquake Study Centre NED NEWSLETTER



The strongest earthquake in 40 years rocks the Indian Ocean.

The 2004 **Indian Ocean Earthquake** was an undersea megathrust earthquake of moment magnitude 9.0 that struck the Indian Ocean off the western coast of northern Sumatra, Indonesia on December 26, 2004 at 00:58:49 UTC (07:58:49 local time in Jakarta and Bangkok). It was the largest earthquake on Earth since the 9.2-magnitude Good Friday Earthquake which struck Alaska, USA, on March 27, 1964, and the fourth largest since 1900. Tens of thousands were killed by the resulting tsunamis, which were as high as 10 m (33 ft) and struck between 15 minutes and 3 hours after the quake, causing one of the most cataclysmic disasters in modern history.

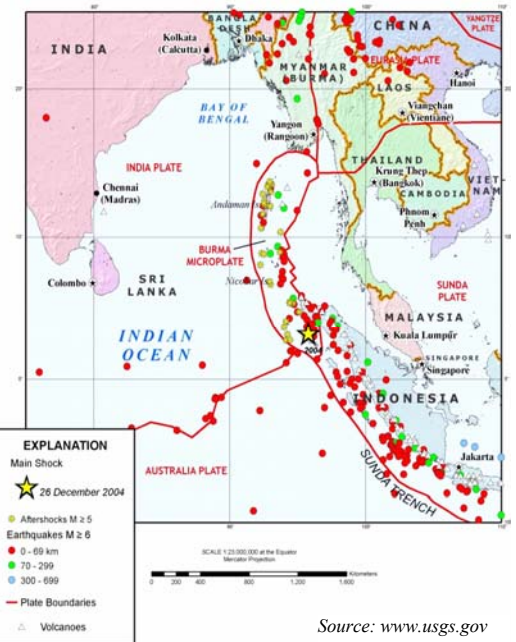
The multiple tsunamis struck and ravaged coastal regions all over the Indian Ocean, devastating regions including the Indonesian province of Aceh, the coast of Sri Lanka, coastal areas of the Indian state of Tamil Nadu, the resort island of Phuket, Thailand, and even as far away as Somalia and several other countries in Africa, 4,500 km (2,800 mi) or more west of the epicenter.

The death toll from the tsunamis and the resultant floods was reported to be more than 130,000 (as on 31-12-2004), with tens of thousands of people reported missing, and over a million left homeless. Governments and NGOs fear the death toll may double as a result of water-borne diseases such as cholera and dysentery, and other diseases such as malaria. Relief agencies report that one-third of the dead appear to be children. In addition to the large number of local residents, some tourists during the busy Christmas holiday travel season were among the casualties.

The death toll may be particularly high due to the fact that this is the first time in over 100 years that a tsunami of the Indian Ocean has struck land, leaving the affected countries unprepared and the people unable to recognise the telltale signs of an impending tsunami. The last tsunami in the area was caused by the eruption of Krakatoa in 1883.

EARTHQUAKE CHARACTERISTICS

The quake was initially reported as 6.8 on the Richter scale. On the moment magnitude scale, which is more accurate for quakes of this size, the earthquake's magnitude was first reported as 8.1 by the United States Geological Survey, but after further analysis they increased this first to 8.5 and 8.9 and finally 9.0.



Source: www.usgs.gov

For comparison, the largest recorded earthquake was the Great Chilean Earthquake of 1960, having a magnitude of 9.5. The only other larger quakes worldwide since 1900 were the 1964 Good Friday Earthquake (9.2) and a March 9, 1957 quake in the Andreanof Islands (9.1), both in Alaska, USA. The only other recorded 9.0 magnitude earthquake, in 1952 off the southeast coast of Kamchatka, U.S.S.R., spawned tsunamis that caused extensive damage in Kamchatka, the Kuril Islands and the Hawaiian Islands. (See Top 10 earthquakes on page 2.)

The hypocenter was at 3.298°N, 95.779°E, some 160 km (100 mi) west of Sumatra, at a depth of 10 km (6.2 mi) underwater, within the "Ring of Fire" zone of frequent earthquakes. The quake itself (apart from the tsunamis) was felt as far away as Bangladesh, India, Malaysia, Myanmar, Thailand and the Maldives.

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EDITORIAL

The publication of this special edition of newsletter is due to the most tragic and sad incident of the Indian Ocean Earthquake and the subsequent Tsunami that devastated the coastal areas of about 12 countries resulting in the loss of hundreds of thousands of precious human lives and trillions of dollars of assets. The United Nations has declared this as the biggest rehabilitation challenge faced in the human history. The catastrophe has caused the damages beyond imagination. It has opened our eyes as to how much we are prepared for the disasters of such a magnitude.

This is an effort to gather knowledge about this Tsunami and Tsunamis in general. The Tsunami hazard in Arabian Sea is also analyzed in the wake of historic and technical information. Cowasjee Earthquake Study Centre NED, shares the grief and expresses its deepest and most sincere condolences to all those who lost life in the recent Tsunami disaster. It is prayed that the humanity prepares itself to be able to cope with such disasters in future.

Casualty Summary

Country	Deaths		Injured	Missing	Displaced
	Confirmed	Estimated			
Indonesia	79,940	80,000	43,869	1,240	108,083
Sri Lanka	27,268	30,000+	8,200+	4,000+	~1.5 million
India	13,230	15,000+	—	10,000	100,000s
Thailand	4,351	6,800	9,810	4,000+	29,000+
Somalia	132	100s	—	—	—
Myanmar (Burma)	90	—	45	14	788
Malaysia	66	—	183	6	5,000
Maldives	75	—	—	29	7,162
Tanzania	10	—	—	—	—
South Africa	2	—	—	—	—
Seychelles	3	—	—	7	—
Bangladesh	2	—	—	—	—
Kenya	2	—	—	—	—
Madagascar	None	—	—	—	1200
Total	123,214	132,000+	510,000	20,000+	3 million-5 million

Note: All figures are as of 31-12-2004 and subject to constant change, taken from various news agencies.

Largest Earthquakes in the World Since 1900

	Location	Date UTC	Magnitude
1.	Chile	1960 05 22	9.5
2.	Prince William Sound, Alaska	1964 03 28	9.2
3.	Andreanof Islands, Alaska	1957 03 09	9.1
4.	Kamchatka	1952 11 04	9.0
4.	Off West Coast of Northern Sumatra	2004 12 26	9.0
6.	Off the Coast of Ecuador	1906 01 31	8.8
7.	Rat Islands, Alaska	1965 02 04	8.7
8.	Assam - Tibet	1950 08 15	8.6
9.	Kamchatka	1923 02 03	8.5
10.	Banda Sea, Indonesia	1938 02 01	8.5
11.	Kuril Islands	1963 10 13	8.5

Source: www.usgs.gov

also reported, including ones of magnitude 7.5 and 6.5 . Other aftershocks between magnitude 5.0 and 6.3 occurred near the location of the original quake.

The total energy released by a magnitude 9.0 earthquake exceeds the total amount of energy consumed in the United States in one month, or the energy released by the wind of a hurricane like Hurricane Isabel over a period of 70 days . Using the mass-energy equivalence formula $E = mc^2$, this amount of energy is equivalent to a mass of about 100 kg (220 lb) (much more than is actually converted to energy in a nuclear explosion), or enough to boil 5000 litres (1,300 US gallons) of water for every person on Earth.

Based on one seismic model, some of the smaller islands southwest of Sumatra have moved southwest up to 20 m (66 ft). The northern tip of Sumatra, which is on the Burma Plate (the southern regions are on the Sunda Plate), may also have moved southwest up to 36 m (118 ft). Other models suggest that most of the movement would have been vertical rather than lateral. Further measurement is needed to determine the extent of any actual movement.

Experts are also entertaining the possibility of a seismic chain reaction across a wider area of Australasia.

Source: www.wikipedia.org, usgs.gov.

Earthquake Characteristics (Continued from page 1)

The earthquake was unusually large in geographical extent. An estimated 1,200 km (740 mi) of faultline slipped 15 m (50 ft) along the subduction zone where the India Plate dives under the Burma Plate. This

formed a shock wave in the Indian Ocean, creating tsunamis that traveled at up to 800 km/h (500 mi/h).

Numerous aftershocks of magnitude between 5.7 and 6.3 were reported off the Andaman Islands in the following hours and days. Aftershocks off the Nicobar Islands were

Damages and Casualties

The earthquake triggered massive tsunamis which struck the coasts of the Indian Ocean resulting in severe damages to life and property. (Source: various news agencies)

INDIA

The entire eastern coast of India was affected, killing more than 11,500 and rendering thousands injured and/or homeless. The death toll in Tamil Nadu, which was most affected, was above 3,200. Along the eastern coast, 487 were killed in Pondichery and 89 in Andhra Pradesh. Kerala, located on the western coast of India,



was also affected with 174 deaths and thousands rendered homeless. Hundreds were feared missing (1,200 in Andhra Pradesh alone). Most of the people killed were fishermen who lived along the coast. Many fishermen both at home and at sea were missing.

Water also rushed into the nuclear reactor complex at Kalpakkam, which was then shut off. No damage or radiation leak was reported.

INDONESIA

Indonesia's Ministry of Health confirmed over 32,000 dead. Nine thousand are reported dead in the provincial capital of Banda Aceh and nearby towns, where dozens of buildings were



destroyed in the initial earthquake. This preliminary figure does not include much of badly damaged western coast of Sumatra. One government official estimated another 10,000 dead in the single town of Meulaboh, 160 km (100 mi) in the northern province of Aceh.

Northern Sumatra was unusual in the regional disaster in that it took damage from the earthquake itself as well as the tsunami. Hundreds of thousands of people have been rendered homeless.

Government officials are very concerned over the lack of reports from the many small islands dotting the western coast of Sumatra.

Most damage was the result of the tsunamis that struck the coastal regions of Aceh and North Sumatra provinces. Ten metre tall tsunamis passed the tip of the island to race south down the Straits of Malacca and strike along the northeast coast near the town of Bireun. The west coast of Sumatra was about 100 km (60 mi) from the epicenter and is believed to have taken heavy damage. At least five villages were completely destroyed. Overflights of the region show that thousands of homes remain underwater.

MALAYSIA

Malaysia escaped the kind of damages that struck beaches thousands of miles further away. This is attributed to the the position of the epicentre which was on the west side of the island of Sumatra, which shielded Malaysia. The limited number of casualties were from people being swept away from beaches as the tsunami hit Malaysia which resulted in the deaths of 63 people as of noon local time: 49 (2 unidentified victims) in Penang, 10 in Kedah, 3 in Perak and one in Selangor. The tremor of the quake was felt by office workers in Petronas Twin Towers.

MALDIVES

Sixty-eight were killed and 76 reported missing in the Maldives, with both figures expected to rise as communication links are restored. Two-thirds of the capital city Malé were flooded during the early hours of the day.

SOMALIA

Villages and coastal communities in Somalia, as far as 4,500 km (2,800 mi) from the epicentre of the earthquake, were swept away and destroyed by the huge waves. Reports say over 100 people are dead. Rising waters engulfed the town mosque of Brava and the villages of Beyla, Garacad, Muduy and Nugaal, all in Puntland, were reported destroyed.

SRILANKA

Sri Lankan authorities report nearly 22,000 confirmed deaths, mostly children and the elderly. The south and east coasts were worst

hit. The army states that over 10,000 bodies have been recovered in government-held areas. The number of dead in Tamil controlled areas is 6000.

More than one million people have been displaced from their homes. Apart from homes,



many hotels were also reported to have been damaged. Hotels along the south coast were full of both foreign tourists and Sri Lankans making use of the long Christmas weekend.

The main highway to the south runs along the coast and was closed in the aftermath of the tsunami, delaying relief supplies.

THAILAND

Thai media reports that over 2,000 are feared dead, with 1,538 confirmed deaths and 8,950 injuries. The popular tourist resort of Phuket was badly hit. The smaller but increasingly popular resort area of Khao Lak some 80 km north of Phuket was hit far worse and there are said to be around 700 corpses on the beach in Khao Lak, while the total amount of dead in Khao Lak may exceed 2,000. The severity of the situation in Khao Lak is probably explained by the fact, that unlike the high-rising city of Phuket, the village of Khao Lak only had low built bungalows instead of high-rise concrete hotels.



Reports say over 700 tourists are among Thailand's casualties. The bodies of 44 foreign tourists are reported to have been recovered at Phuket. Hundreds of holiday bungalows on the Phi Phi Islands were washed out to sea.

Tsunami– The Killer wave!

What is a Tsunami?

A **tsunami** (from Japanese meaning *wave in port* or "harbour wave") is one or a series of ocean surface waves that can occur after a large earthquake (having a vertical component of movement), seaquake, volcanic activity, landslide, slumps, or meteorite impacts in or near the sea. Tsunamis are sometimes referred to as **tidal waves** as they often resemble a tide that keeps rising, rather than cresting waves when they reach shore. However, the term is misleading as tsunamis are not caused by tides, and its use is being discouraged by oceanographers. While it has also been noted that tsunamis often have little to do with harbors (despite the Japanese translation of the word), the term "tsunami" is used exclusively to refer to water surges caused by physical displacement of water and is thus *more* correct.

Evidence shows that megatsunamis, which are caused by significant chunks of an island collapsing into the ocean, are also possible.

Physics of a Tsunami

In deep water, the energy of a tsunami is constant, a function of its height and speed. Thus, as the wave approaches land, its height increases while its speed decreases. A tsunami has a very long wave length (in the order of 100 km), which makes it act as a shallow-water

wave. Since the speed of a shallow-water wave is $(gd)^{1/2}$, where g is the gravitational acceleration and d is the water depth, a tsunami in the open ocean can obtain a speed of about 700 km/h. While in deep water a person at the surface of the water would probably not even notice, the wave can increase to a height of 30 m and more as it approaches the coastline. Tsunamis can cause severe destruction on coasts and islands.

Warning Systems

Many cities around the Pacific, notably in Japan have warning systems and evacuation procedures in the event of a serious tsunami. Tsunamis are predicted by various seismologic institutes around the world and their progress monitored by satellites. The first rudimentary system to alert communities of an impending tsunami was attempted in Hawaii in the 1920s. More advanced systems were developed in the wake of the April 1, 1946 and May 23, 1960 tsunamis which caused massive devastation in Hilo, Hawaii. The United States created the Pacific Tsunami Warning Center in 1949, and linked it to an international data and warning network in 1965.

Tsunami prediction remains an imperfect science. Although the epicenter of a large underwater quake and the probable tsunami arrival times can be quickly calculated, it is

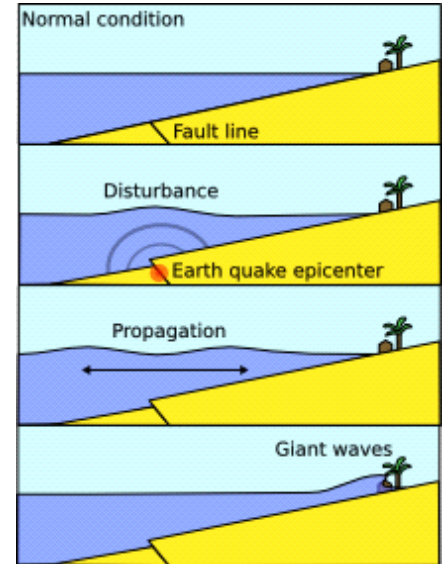


Fig. 1: Generation of a Tsunami

almost always impossible to know whether massive underwater ground shifts have occurred, resulting in tsunami waves. As a result, false alarms are common.

Source: www.wikipedia.org

Tsunamis Hazard in Arabian Sea

A question that perplexes every person's mind is: "How safe my region is from dangerous and devastating Tsunamis?"

Both history and scientific research reveal the answer to this question. Though rare and relatively unheard of, tsunamis have struck the shores of South Asia in the past. The deadliest was in 1945, which originated off the Mekran coast in Pakistan and caused deaths as far as Mumbai. In earliest known tsunami occurred in the Bay of Bengal in 1762, caused by an earth-

quake on Myanmar's, Arakan Coast.

This was the last major tsunami-generating earthquake in the Arabian Sea. More than 4000 people were killed on the Makran Coast by both the earthquake and the tsunami. The most significant aspect of this earthquake was the tsunamis that it triggered. The tsunami reached a height of 40 feet in some Makran ports and caused great damage to the entire coastal region.

Date	Location
1524	Near Dabhol, Maharashtra
02 April 1762	Arakan Coast, Myanmar
16 June 1819	Rann of Kachchh, Gujarat
31 October 1847	Great Nicobar Island
31 December 1881	Car Nicobar Island
26 August 1883	Krakatoa volcanic eruption
28 November 1945	Mekran coast, Balochistan

In the most recent study of Jones and Johnson, they have studied the hazard posed to the coastal region of Pakistan and concluded:

"A complex system of geologic faults runs northwest in Gujarat, while concealed under the loose sediments of the Indus delta this system of faults appears to continue to the west passing through the metropolitan area of Karachi. The fault extends into the Arabian Sea, where it intersects another system of faults associated with a major tectonic boundary. Karachi sits very close to a geologic triple junction- where three tectonic

plates meet. An earthquake of similar magnitude to the Bhuj Earthquake of 2001 occurring in the ocean off Karachi could generate a Tsunami traveling inland suddenly to engulf the city's most densely populated areas to rival the effects of nuclear weapons".

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Information, news items, short notes on research findings are invited from across the globe.