

Preliminary Assessment of Impact of Tsunami in Selected Coastal Areas of India



Compiled by

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1. Background

Tsunamis are among the most terrifying natural hazards known to man and have been responsible for tremendous loss of life and property throughout history. Because of their destructiveness, tsunamis have notable impact on the human, social and economic sectors of our societies. In the Pacific Ocean, where the majority of these waves have been generated, the historical record shows wide scale destruction. In Japan, which has one of the most populated coastal regions in the world and a long history of earthquake activity, tsunami has destroyed large coastal populations. There is also a history of tsunami destruction in Alaska, in the Hawaiian Islands in South America, Japan and elsewhere in the Pacific.

Destructive tsunamis have also occurred in the Indian Ocean and in the Mediterranean Sea. The most notable tsunami in the region of the Indian Ocean was that associated with the violent explosion of the volcanic island of Krakatoa in August 1883. A 30 m (100 feet) tsunami resulting from this explosion killed 36,500 people in Java and Sumatra. The violent eruption and explosion of the volcano of Santorin, in the fifteenth Century B.C. generated a giant tsunami which destroyed most of the coastal Minoan settlements on the Aegean Sea islands acting as the catalyst for the decline of the advanced Minoan civilization.

Tsunamis that can travel across an ocean and attack a coastal area far away from the source of generation are called distant Tsunamis or Teletsunamis, while tsunamis that are confined in an area near the source are called local Tsunamis.

2 The Physics of Tsunamis - the mechanisms of generation and propagation

2.1 What is a Tsunami?

A Tsunami is a wave train, or series of waves, generated in a body of water by an impulsive disturbance that vertically displaces the water column. Earthquakes, landslides, volcanic eruptions, explosions, and even the impact of cosmic bodies, such as meteorites, detonation of nuclear devices near the sea can give rise to such

destructive sea waves so called Tsunamis. By far the most destructive tsunamis are generated from large shallow-focus earthquakes with an epicenter or fault line near or in the ocean. Vertical displacements of the earth's crust along the rupture resulting from such earthquakes can generate destructive tsunami waves which can travel across an ocean spreading destruction across their path. Although the sources for formation of tsunami are considered as point sources, the tsunami waves generated can be very destructive locally, the energy of the waves is rapidly dissipated as they travel across the ocean, can ravage coastlines, causing property damage and loss of life. The speed of the tsunami is governed by the water depth. Speed reduces and wave height increases as it approaches the shore.

2.2 What does "Tsunami" mean?

Tsunami is a Japanese word with the English translation, "harbour wave". Represented by two characters, the top character, "tsu" means harbour, while the bottom character, "nami" means "wave." In the past, tsunamis were sometimes referred to as "tidal waves" by the general public, and as "seismic sea waves" by the scientific community. The term "tidal wave" is a misnomer; although a tsunami's impact upon a coastline is dependent upon the tidal level at the time a tsunami strikes, tsunamis are unrelated to the tides. Tides result from the imbalanced, extraterrestrial, gravitational influences of the moon, sun, and planets. The term "seismic sea wave" is also misleading. "Seismic" implies an earthquake-related generation mechanism, but a tsunami can also be caused by a nonseismic event, such as a landslide or meteorite impact.

2.3 Influence of earthquakes in generating Tsunamis

If man has a way of demarcating and classifying the various regions of earth into several countries and continents, nature has its own way too. The earth's surface is not one continuous piece of landmass. On the other hand, it is broken up into several large and small plates. A plate (also called lithospheric plate) is a massive, irregularly shaped slab of solid rock, generally composed of both continental and oceanic lithosphere. These plates, each about 50 miles thick, are not anchored to a particular place; they move relative to one another at an average speed of a few

inches a year. And earthquakes and volcanic eruptions occur when these plates collide at their boundaries.

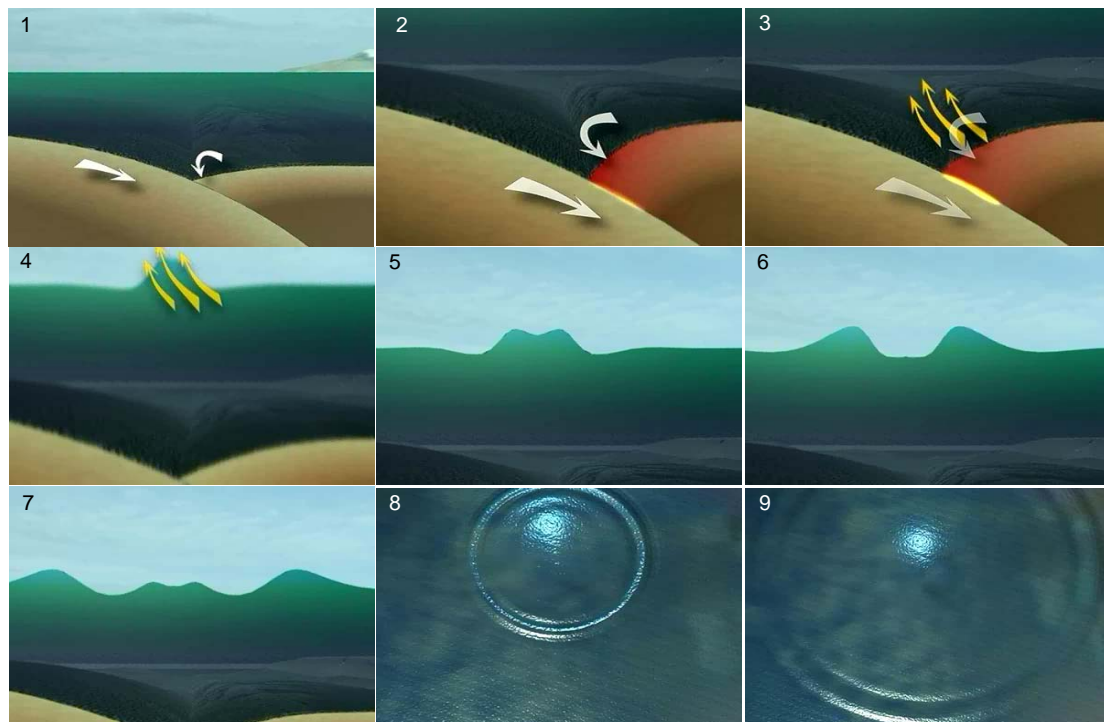
But not all plate movements lead to collision. Three types of movement are recognized at the boundaries between plates: convergent, divergent and transform. At the divergent boundaries new crust is formed when lava flows out pushing the plates away from each other; convergent boundaries, on the other hand, lead to plate destruction as one plate dives (subducts) under another. Crust is neither created nor destroyed at the transform boundaries as the plates just slide past each other horizontally. The formation of new crust, called sea floor, spreading at the divergent boundaries and destruction at convergent plate boundaries happen at the same rate globally. And this is the essence of plate tectonics, which goes to explain how volcanic eruptions, and earthquakes that ravage the earth's surface happen.

Tsunamis can be generated when the sea floor abruptly deforms and vertically displaces the overlying water. Tectonic earthquakes are a particular kind of earthquake that are associated with the earth's crustal deformation; when these earthquakes occur beneath the sea, the water above the deformed area is displaced from its equilibrium position (Fig.1). Waves are formed as the displaced water mass, which acts under the influence of gravity, attempts to regain its equilibrium and the size of the resultant tsunami waves is determined by the quantum of the deformation of the sea floor. More the vertical displacement, greater will be the size of the waves. As a rule, all earthquakes do not produce tsunamis. When large areas of the sea floor elevate or subside, a tsunami can be created.

Large vertical movements of the earth's crust can occur at plate boundaries. Plates interact along these boundaries called faults. Around the margins of the Pacific Ocean, for example, denser oceanic plates slip under continental plates in a process known as subduction. Subduction earthquakes are particularly effective in generating tsunamis. The earthquake's magnitude, depth, fault characteristics and coincident slumping of sediments or secondary faulting also determine the size of the tsunamis.

If plate interactions on land cause earthquakes, those that occur in the sea pose the biggest risk of generating tsunamis. Earthquakes occurring on land do not cause

death directly; buildings that collapse do. Similarly, earthquakes that occur in the sea do not kill life; tsunamis that are produced by them do.



(Courtesy: Prof. Miho Aoki, University of Alaska)

FIG 1. Visualisation of Tsunami generation by a subduction zone earthquake

2.4 Influence of landslides, volcanic eruptions and cosmic collisions in generating Tsunamis

A tsunami can be generated by any disturbance that displaces a large water mass from its equilibrium position. In the case of earthquake-generated tsunamis, the water column is disturbed by the uplift or subsidence of the sea floor. Submarine landslides, which often accompany large earthquakes, as well as collapses of volcanic edifices, can also disturb the overlying water column as sediment and rock slump downslope and are redistributed across the sea floor. Similarly, a violent submarine volcanic eruption can create an impulsive force that uplifts the water column and generates a tsunami. Conversely, supermarine landslides and cosmic-body impacts disturb the water from above, as momentum from falling debris is transferred to the water into which the debris falls. Generally speaking, tsunamis generated from these mechanisms, dissipate quickly and rarely affect coastlines distant from the source area.

2.5 Difference between Tsunami waves and other water waves

Wind flowing across a lake or ocean can create wrinkles on the water surface and produce short waves restricted to shallow layer. Tides (high and low) that sweep the globe every day also produce waves. Means by which tsunamis generated have been explained in the previous sections.

Tsunamis are unlike wind-generated waves, which are observed on a local lake or at a coastal beach, in that they are characterized as shallow-water waves, with long periods and wave lengths. The wind-generated waves are rhythmically rolling in, one wave after another, might have a period (time between two successive waves) of about 10-20 seconds and a wave length (distance between two successive waves) of 100-200 m. A tsunami, on the other hand, can have a wavelength in excess of 500 km and period of ten minutes to two hours (Fig.2). It is because of their long wavelengths that tsunamis behave as shallow-water waves. Tsunamis are often taller than normal wind waves, but they are much more dangerous.

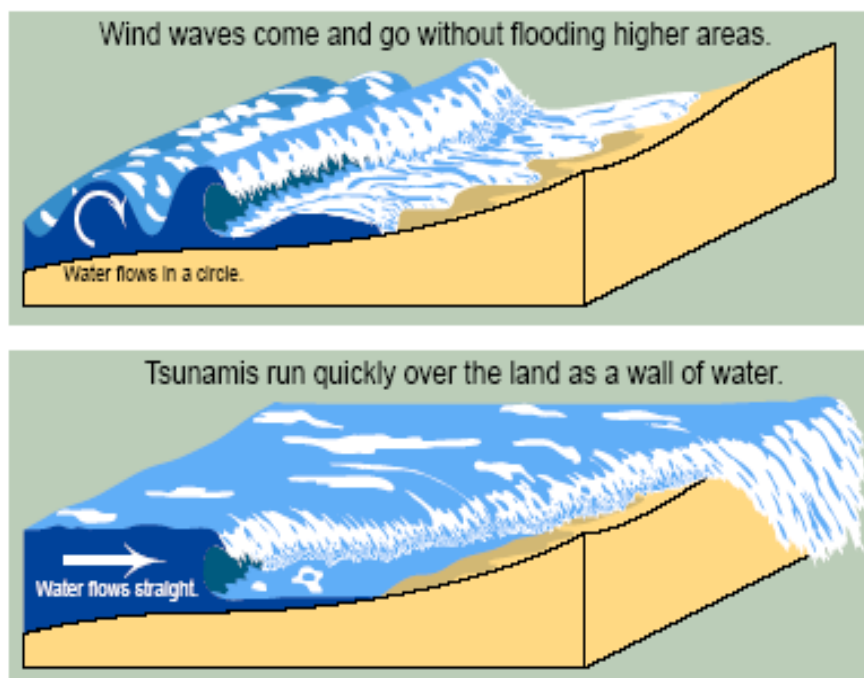


FIG 2. Difference between Wind waves and Tsunami waves
(Courtesy: www.ess.washington.edu/tsunami/index.htm)

2.6 Tsunamis travel to long distance

As a result of their long wave lengths, tsunamis behave as shallow-water waves. A wave becomes a shallow-water wave when the ratio between the water depth and its wave length gets very small and the rate at which a wave loses its energy is inversely related to its wavelength. Since tsunamis have a very large wavelength, in excess of 500 km, it will lose little energy as it propagates. Shallow-water waves move at a speed that is equal to the square root of the product of the acceleration of gravity (9.8 m/s) and the water depth. Hence in very deep water, a tsunami will travel at high speeds and travel great distances with limited energy loss. For example, when the ocean is more than 5000 m deep, unnoticed tsunami travel about 890 km/hr, the speed of a jet airplane and at 1000 m water depth it would travel at 356 km/hr. So a tsunami travels at different speeds in the ocean; slow in shallow water and fast in deep water. Because the rate at which a wave loses its energy is inversely related to its wave length, tsunamis not only propagate at high speeds, they can also travel great, transoceanic distances with limited energy losses.

But what in the first place provides the force needed to allow a tsunami to travel a long distance? Tsunamis are what are called long gravity waves. There are two interacting processes that allow these waves to propagate. The first is the slope of the sea surface, which creates a horizontal pressure force. The second is the piling up (or lowering of sea surface) as water moves with different speeds in the direction that the wave form is moving. When these two processes have the right relationship in time, they create propagating waves.

As the tsunami crosses the deep ocean, its wavelength (distance from crest to crest) may be hundred kilometres or more and its amplitude (height from crest to trough) will be in the order of a few feet or less. They cannot be felt aboard ships nor can they be seen from the air in the open ocean. However, radar satellites can detect these changes.

2.7 What happens to a Tsunami as it approaches land?

As a tsunami leaves the deep water of the open ocean and travels into the shallower water near the coast, it transforms and travels at a speed that is related to the water

depth - hence, as the water depth decreases, the tsunami slows. The tsunami's energy flux, which is dependent on both its wave speed and wave height, remains nearly constant. They race onto shallow water regions, pass into continental coasts and their speed diminishes which results in increase in the wave height in order to conserve the total energy. This results in decreasing the distance between individual waves in a process called 'shoaling'. The conservation of energy requires that the amplitudes (height) of the waves grow larger as the waves slow down. The height of the wave rises up to 30 feet or more and the total energy of the tsunami remains a constant. Because of this shoaling effect, a tsunami, imperceptible at sea, may grow to be several meters or more in height near the coast. When it finally reaches the coast, a tsunami may appear as a rapidly rising or falling tide, a series of breaking waves, or even a bore (Fig.3).

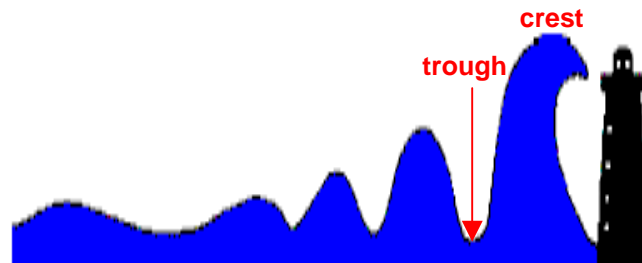


FIG 3. Movement of Tsunami waves as it reaches towards coast

2.8 What happens when a Tsunami encounters land?

As a tsunami approaches shore it begins to slow and grow in height. Just like other water waves, tsunamis begin to lose energy as they rush onshore - part of the wave energy is reflected offshore, while the shoreward-propagating wave energy is dissipated through bottom friction and turbulence. Despite these losses, tsunamis still reach the coast with tremendous amounts of energy. Tsunamis have great erosional potential, stripping beach sand, undermining trees and other coastal vegetation. Capable of inundating, or flooding, hundreds of meters inland past the typical high-water level, the fast-moving water associated with the inundating tsunami can crush homes and other coastal structures. Tsunamis may reach a maximum vertical height onshore above sea level, often called a 'run-up height', of 10, 20 and even 30 meters especially near the coast (Fig.4).

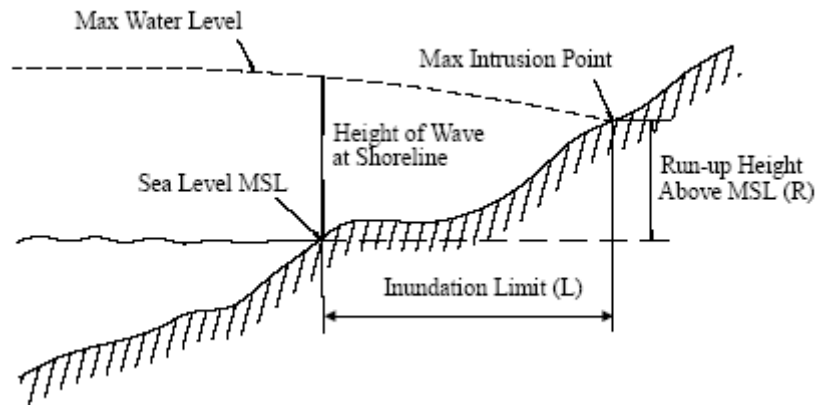


FIG 4. Schematic diagram showing measurement of Run-up height.

(Courtesy: Gica & Teng, 2003)

Run-up is usually expressed in meters above normal tide or Mean Sea Level. Run-ups from the same tsunami can be variable because of the influence of the geomorphology (shape) of the coastline. In one coastal area destructive waves can be large and violent with large damaging activity, while in another area without being violent cause extensive flooding with rise in water level to a few meters. The inundation of the area can be up to 2 to 5 km inland especially at locations where estuaries that have good depth profile. While retreating, the waves with considerable velocity tend to carry loose objects and people out to sea. The extent of damage depends on extent of run up height, velocity of the water, local topography and land utility pattern (say settlement, agriculture, forestry etc). The loss of human life in a single tsunami could be as much as 1,00,000 and damage to properties to several millions of dollars.

2.9 Receding of ocean as a signal of Tsunami at coast

The arrival of tsunami wave to the coast can be different. The crest of the wave isn't the first to arrive - the trough is. This is often the case when the tsunami originates from an oceanic earthquake associated with land subsidence or sinking, which causes the water column to drop down at the earthquake site. In this case, instead of extremely high water levels, the first sign of a tsunami is what appears to be an unusually low-tide (Fig.5). Although onlookers might be intrigued by this unusual

site, this major withdrawal of the sea should be taken as a warning that a tsunami wave will soon follow.

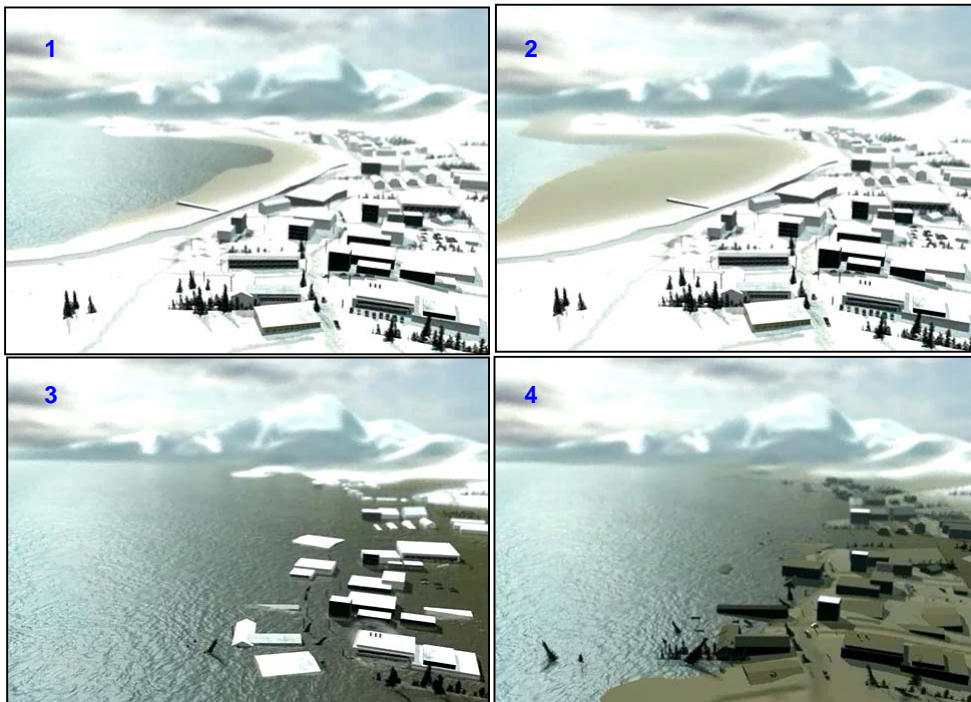


FIG 5. Computer animated visuals of Tsunami seen at the coast
Receding of sea is seen first followed by inundation of coastal area.
(courtesy: Prof. Moho Aoki, University of Alaska)

As the coastal ocean waters recede from the shore, it often leaves large portions of the sea floor exposed. Individuals who do not recognize this as a common precursor to tsunami waves often find themselves gravitating toward the exposed shore. Experts believe that a receding ocean may give individuals more familiar with “nature’s tsunami warning signal” as much as a five-minute warning to evacuate the area. This cycle may be repeated several times as successive wave crests arrive five minutes to an hour apart.

2.10 Understanding Tsunami Source Mechanism and Potential Terminal Runup

To forecast tsunamis and determine terminal runup and destructiveness, one must be able to evaluate the parameters of the tsunami source mechanism in real time, often from inadequate data. Tsunami source mechanism analysis is difficult given the time constraints of a warning situation. Despite the great speed, tsunami waves travel much slower than the seismic waves. Hence earthquake information is often

available hours before the tsunamis are able to travel across the ocean. It will suffice to say that forecasting the runup and potential destructiveness of a tsunami at a distant shore will depend greatly on determining the seismic parameters of the source location such as magnitude of the earthquake, its depth, its orientation, the length of the fault line, the size of the crustal displacements, and depth of the water. Refraction and diffraction processes will affect the energy and height of the tsunami waves as they travel across the ocean. These effects must also be determined. Finally, terminal height, run-up, and inundation of the tsunami at a point of impact will depend upon the energy focusing effect, the travel path of the waves, the coastal configuration, and the offshore bathymetry, only to name a few.

Tsunami run-up is the vertical distance between the maximum height reached by the water on shore and the mean-sea-level surface. Contrary to meteorological predictions, tsunami run-up is not possible to forecast with a great degree of accuracy. The reason for this inadequacy is that the Tsunami Warning System works in a real time frame of short duration, often with inadequate data and information. Problems of communications and lack of sufficient station density, often complicate the process. Forecasting tsunamis requires adequate understanding of the phenomenon, good and expeditious collection of earthquake and sea level data, and accurate and expeditious assessment and interpretation of this data.

3 History of Tsunamis in the world and extent of inundation

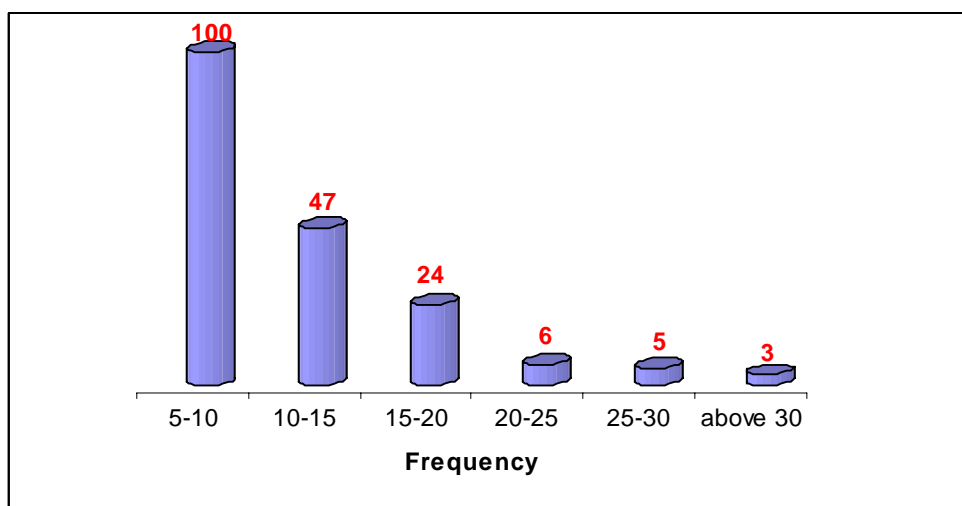
Tsunamis are generated when the epicenter of an earthquake having a magnitude of more than Ms 7.0 located on seabed. In the Pacific Ocean where the tsunamis occur mostly, 79 tsunamis were observed with 117 casualties but with extensive damages to properties. According to the Tsunami Laboratory in Novosibirsk during the 101-year period from 1900 to 2001, 796 tsunamis were observed or recorded. 117 caused casualties and damage most near the source only. At least nine caused widespread destruction throughout the Pacific. The greatest number of tsunamis during any one year was 19 in 1938, but all were minor and caused no damage. There was no single year of the period that was free of tsunamis. Details of Run up levels occurred during last one decade in the Pacific is given in Table 1.

TABLE 1. Run up levels recorded during Tsunamis occurred between 1992 and 2001 in the Pacific Ocean

Date	Location	Magnitude of earthquake at source (M)	Max Run-up (m)	Killed (nos.)
09.02.92	Nicaragua	7.2	10	170
12.12.92	Flores Island	7.5	26	1000
07.12.93	Hokkaido	7.6	30	200
06.02.94	Java	7.2	14	220
10.04.94	Kuril Island	8.1	11	11
11.14.94	Nubdiri	7.1	7	70
02.21.96	Peru	7.5	5	12
07.17.98	New Guinea	7.0	15	2000
06.23.01	Peru	8.3	5	50

Source: Pacific Tsunami Warning Centre (<http://www.prh.noaa.gov/ptwc/aboutTsunamis.htm>)

In the Pacific region, 17% of the total tsunamis were generated in or near Japan. The distribution of tsunami generation in other areas is as follows: 15% in South America, 13% in New Guinea Solomon Islands, 11% in Indonesia, 10% in Kuril Islands and Kamchatka, 10% in Mexico and Central America, 9% in Philippines, 7% in New Zealand and Tonga, 7% in Alaska and West Coasts of Canada and the United States, and 3% in Hawaii.



(Source: National Geophysical Data Centre, NOAA)

FIG 6. Frequency distribution map showing Tsunami Runup heights (m) from all over the world during 1940-2004

The history of tsunamis generated all over the world since 1940 revealed that the tsunami runup height of 5-10 m was recorded for maximum number of times and the intensity of tsunami occurrences decreased with increasing runup heights (Fig.6). Run-up heights between 20 and 30 m occurred for 11 times while that exceeding 30 m recorded only thrice.

3.1 History of Tsunamis affecting Indian Ocean

Although not as frequent as in the Pacific Ocean, tsunamis generated in the Indian Ocean pose a great threat to all the countries of the region. The most vulnerable are: Indonesia, Thailand, India, Sri Lanka, Pakistan, Iran, Malaysia, Myanmar, Maldives, Somalia, Bangladesh, Kenya, Madagascar, Mauritius, Oman, Reunion Island (France), Seychelles, South Africa and Australia.

Tsunamis occur seldom in the Indian Ocean region, and in the last 300 years, this region recorded 13 tsunamis (Table 2) and 3 of them occurred in Andaman and Nicobar region for which the details of location of epicentre, death/damage caused etc. are not known, data on run-up heights indicate to the extent of 4 m in Port Blair with Nicobar recording very low (0.76 m). Among these, the 1945 tsunami had a maximum run up of 13 m in Pakistan and resulted in death of 4000 people following an earthquake of magnitude 8.2 Ms in the Arabian Sea. Overall, the run-up levels varied from 1 to 13 m. In 1977, one of the strongest earthquake of magnitude Ms 8.1 struck west of Sumba Island in Indonesia, but there were no reports of casualties in India due to this tsunami. Apart from those listed in Table 2, there may be additional destructive tsunamis in the Indian Ocean that have not been properly documented. For example villagers of Simeulue Island, off the coast of Sumatra, speak of a destructive tsunami in 1907 that had killed thousands of people.

TABLE 2. Run-up level for Tsunami occurred between 1700 and 2004 in the Indian Ocean

S. No	Name of affected location	Run up heights (m)	Year/ Date	Earthquake Magnitude at source	Source location
1.	Tributaries of the Ganges river (Bangladesh)	1.83	12.04.1762	NA	Bay of Bengal
2.	--	--	1847	--	Great Nicobar Island
3.	Port Blair, Andaman Islands	4.00	19.08.1868	MW 7.5	Bay of Bengal
4.	Car Nicobar Island, Nicobar Islands	0.76	31.12.1881	MS 7.9	Car Nicobar Islands, Andaman Sea
5.	Dublat, India	0.30			
6.	Nagapattinam, India	1.22			
7.	Port Blair, Andaman Islands	1.22			
8.	Chennai	1.5 (wave height)	26.08.1883	Krakatao volcanic eruption	Islands of Java and Sumatra
9.	Andaman & Nicobar Islands	NA	26.6.1941	MW 7.7	Andaman Sea (12.5°N; 92.57°E)
10.	Mumbai, India	1.98	27.11.1945	MS 8.3	Arabian Sea (24.5°N; 63°E)
11.	Karachi, Pakistan	1.37			
12.	Ormara, Pakistan	13.00			
13.	Pasni, Pakistan	13.00			
14.	Victoria, Mahe Island, Seychelles	0.30			
15.	Not felt in India	--	19.08.1977	MS 8.1	West of Sumba Island, Indonesia (11.09°S; 118.46°W)
	Cocos Islands, Australia	0.30	18.06.2000	MS 7.8 MW 7.9	Arabian Sea

Source: National Geophysical Data Centre, NOAA, USA
(www.ngdc.noaa.gov/nmdc/servlet/ShowDatasets)

4 Seismotectonics of the Indian Ocean region and potential Tsunami generating sources

Harsh Gupta (2005) stated that globally there are three major belts which account for almost 95% of earthquake activity. According to him, the belt along which most of the earthquakes occur is called the Circum-Pacific belt which goes around the rim of the Pacific Ocean. The second most active belt is the Alpide-Himalaya seismic belt which starts from southeast Asia near Java-Sumatra, continues through Andaman Nicobar Islands, India-Burma border region, swings through north of India in the foothills of Himalayas and then moves west through Iran into Greece and Italy. The third major seismic belt consists of mid-oceanic ridges which account for small magnitude earthquakes. These can be seen in Pacific, Atlantic and Indian Oceans. Majority of earthquakes occur at shallow depths (0-70 km) whereas some occur at intermediate depths (70-300 km) and a few at deeper depths (300-700 km).

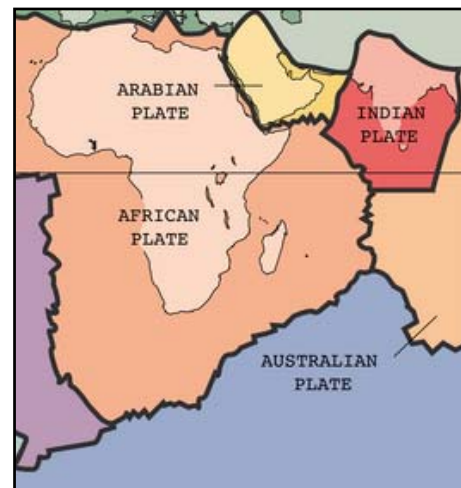
Although not as destructive as the 26 December 2004 event was, many more tsunamis have been generated by large earthquakes in subduction zones bordering the Indian Ocean and by smaller magnitude events along the Central Indian and Carlsberg mid-oceanic ridges. Among the major tsunamis listed in Table 2, the Krakatao volcanic eruption generated the deadliest tsunami in 1883 which killed 37,000 people in the islands of Java and Sumatra.

Scientists at Columbia University's Lamont-Doherty Earth Observatory (LDEO) report direct evidence that one of the Earth's great crustal plates is cracking in two. Orman et al. (1995), have confirmed that the Indo-Australian Plate, long identified as a single plate on which both India and Australia lie, appears to have broken apart just south of the Equator beneath the Indian Ocean. The break has been underway for the past several million years, and now the two continents are moving independently of one another in slightly different directions. According to USGS, the India tectonic plate has been drifting and moving in a north/northeast direction for some 50 million years, colliding with Eurasian tectonic plate and forcefully raising the Tibetan Plateau and the Himalayan Mountains (Fig.7). As a result of such migration and collision with both the Australian and the Eurasian tectonic plates and subplates, the Indian plate's eastern boundary is a diffuse zone of seismicity and deformation,

characterized by extensive faulting and earthquakes that can generate moderate to destructive tsunamis.



FIG 7. Migration of Indian Tectonic Plate (Source: USGS)



(Source: USGS)

FIG 8. Tectonic plates of Indian Ocean.

In the western part of Indian Ocean, the interaction of the India plate with the Arabian and Iranian microplates of the Eurasian block has created an active subduction zone along the Makran coast of Pakistan (Fig.8). A major fault in this region has produced tsunamigenic earthquakes recently and in the distant geologic past. This major fault is of the same character as the West Coast fault along the coast of Maharashtra, India - which is also a region that can produce tsunamigenic earthquakes. Further south on the western side the Indian tectonic plate is bounded by the Central Indian and Carlsberg mid-ocean ridges, a region of shallow seismicity. To the east, subduction of the Indo-Australian Plates beneath the Burma and Sunda Plates has formed the extensive Sunda Trench - a very active seismic region where large earthquakes are frequent. The volcanoes of Krakatau, Tambora and Toba, well known for their violent eruptions, are byproducts of such tectonic interactions. A divergent boundary separates the Burma plate from the Sunda plate in the north. The Burma plate encompasses the northwest portion of the island of Sumatra as well as

the Andaman and the Nicobar Islands, which separate the Andaman Sea from the Indian Ocean.

Destructive tsunamis can originate from earthquakes that occur along these principal tectonic sources. The major tectonic feature in the region is the Sunda Arc that extends approximately 5,600 km between the Andaman Islands in the northwest and the Banda Arc in the east. The Sunda Arc consists of three primary segments; the Sumatra segment, the Sunda Strait Segment and the Java Segment. These locations represent the area of greatest seismic exposure, with earthquake magnitudes of 8 or even more on the Richter scale - as the 26 December 2004 proved. Active tectonic interaction of this great arc has produced destructive earthquakes and tsunamis in the distant past and as recently as 1977, 1992 and 1994.

4.1 Earthquake of 26th December 2004:

On 26th December 2004, the Indian coastline experienced the most devastating tsunami in recorded history. The tsunami was triggered by an earthquake of magnitude Mw 9.3 at 3.316°N, 95.854°E off the coast of Sumatra (Fig.9) in the Indonesian Archipelago at 06:29 hrs making it the most powerful in the world in the

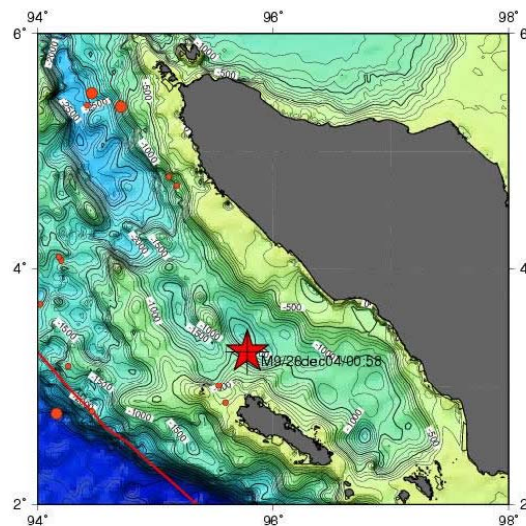
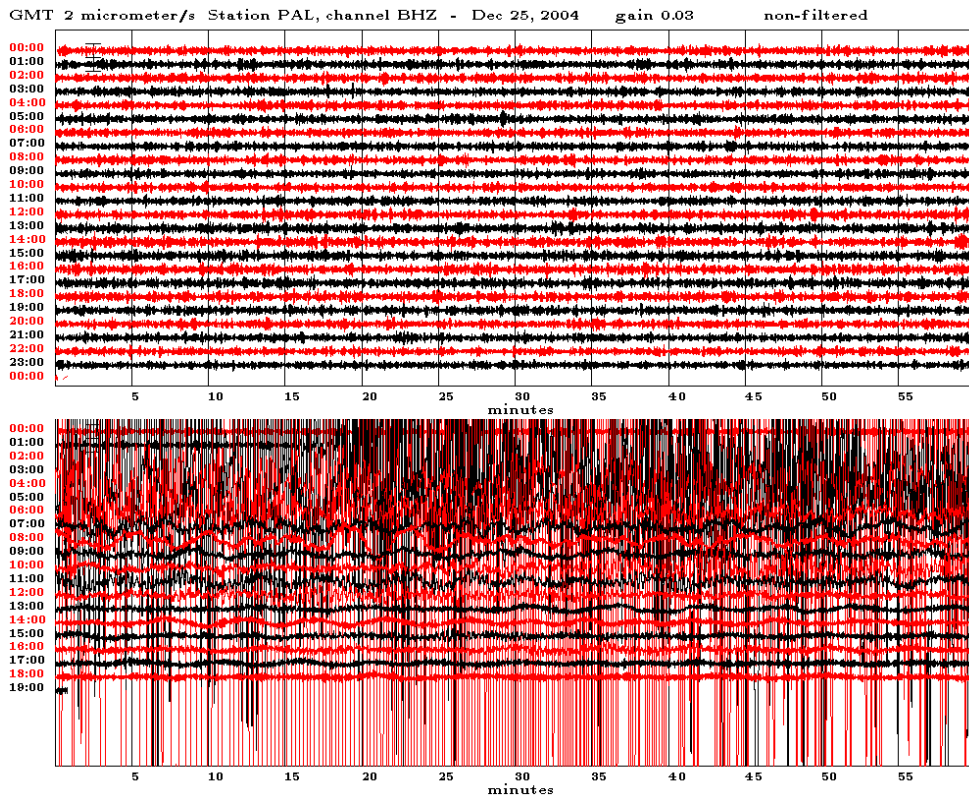


FIG 9. The topography at the site of the main seismic event (MW 9.3) generated using world digital topo data. According to this, the location of the event is about 1300 m deep from surface of the water (Source: USGS).

last 40 years. In confirmation to this, the recorded seismographs of LDEO show that at around 01:20 GMT on December 26, 2004 there was extraordinary oscillations that subsided 12 hours later. The seismograph for the previous day has shown regular activity (Fig. 10) but goes off the chart around 01:20 GMT and then subsides by 06:45 GMT. However, things did not become normal until 15:00 GMT.



(Source: Lamont-Doherty Earth Observatory, Columbia University)

FIG 10. Seismographs for the periods 25th and 26th December 2004

The earthquake of 26th December 2004 occurred off northwest of Sumatra is not an unusual earthquake from the Plate Tectonics point of view. It has occurred in the vicinity of seismically active zone, close to Sunda Trench in the water depths of about 1300 m. The earthquake epicenter is located relatively at shallow depth, about 10 km below the ocean floor. The high magnitude, Mw 9.3 of the earthquake and its shallow epicenter have triggered tsunami in the northeast Indian Ocean. These were travelled in open ocean of the Bay of Bengal and subsequently transformed into a train of catastrophic oscillations on the sea surface close to coastal zones of Sri Lanka, east and west coasts of India.