

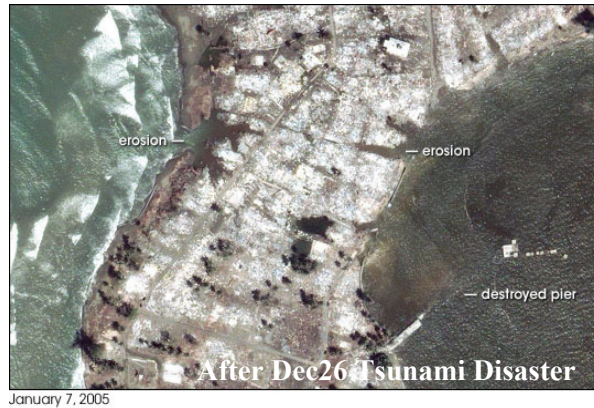
TSUNAMI DISASTER IN SOUTH ASIA

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On December 26, 2004, a devastating severe earthquake (magnitude 9.0) occurred off the western coast of Sumatra in the Indian Ocean. The earthquake was caused by the release of stresses accumulated as the Burma tectonic plate overrides the India tectonic plate. Movement of the seafloor due to the earthquake generated a tsunami, or seismic sea wave, that affected coastal regions around the Indian Ocean. The northwestern Sumatra coastline in particular suffered extensive damage and loss of life.

The Indonesian province of Aceh was hit hardest by the earthquake and tsunamis of December 26, 2004. Aceh is located on the northern tip of the island of Sumatra. Early Western media attention was focused on Sri Lanka and Thailand, even though the earthquake epicenter was closer to Aceh, and the largest waves struck the northwestern coast of Sumatra. On December 29, estimates of the death toll in Indonesia were over 80,000—more than half the global total. The town of Lhoknga, on the west coast of Sumatra near the capital of Aceh, Banda Aceh, was completely destroyed by the tsunami, with the exception of the mosque in the city's center.

Satellites continued to acquire imagery of areas severely damaged by the tsunami of December 26, 2004. This image of Meulaboh, Indonesia, was collected on January 7, 2005, by [DigitalGlobe's](#) QuickBird satellite. Meulaboh is located on the coast of Sumatra, roughly 150 kilometers (93 miles)



Lhoknga – A town on west coast of Samarta

from the epicenter of the magnitude 9.0 earthquake that generated the tsunami. The image shows where the tsunami washed over a narrow peninsula, eroding the beach and destroying many of the town's buildings.

The high-resolution satellite images, acquired by Space Imaging's Ikonos satellite, show Lhoknga before and after the earthquake and Tsunami depict that almost all the trees, vegetation, and buildings in the area were washed away. Low-lying agricultural areas remained covered with water four days after the disaster, and sand on the nearby beaches was completely removed. The wave height might have exceeded 15 meters (50 feet) when it struck the shore.

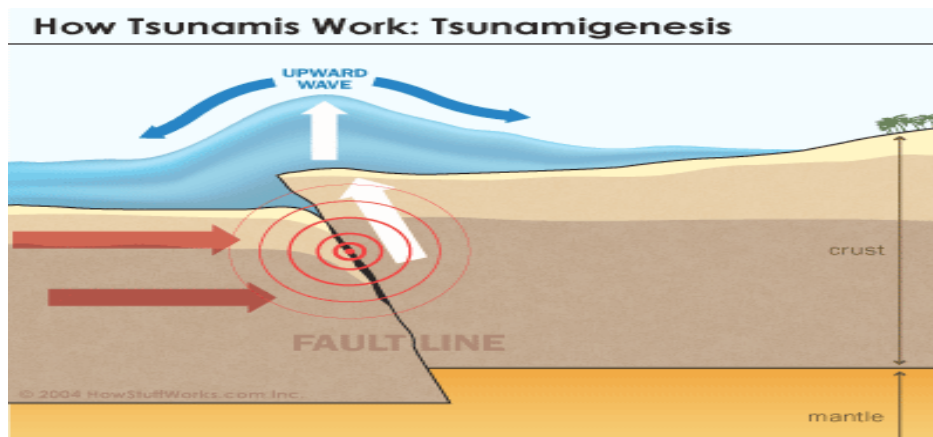
Basics about Tsunamis:

The word Tsunami (pronounced tsoo-nah'-mee) is composed of the Japanese words "tsu" (which means harbor) and "nami" (which means "wave"). The phenomenon we call tsunami is a series of large waves of extremely long wavelength and period usually generated by a violent, impulsive undersea disturbance or activity near the coast or in the ocean. When a sudden displacement of a large volume of water occurs, or if the sea floor is suddenly raised or dropped by an earthquake, big tsunami waves can be formed by forces of gravity. The waves travel out of the area of origin and can be extremely dangerous and damaging when they reach the shore.

The tsunami waves are completely unrelated to the astronomical tides - which are caused by the extraterrestrial, gravitational influences of the moon, sun, and the planets. Thus, the Japanese word "tsunami", meaning "harbor wave" is the correct, official and all-inclusive term. It has been internationally adopted because it covers all forms of impulsive wave generation.

The Science of Tsunami

There are many causes of tsunamis but the most prevalent is earthquake. In



addition, landslides, volcanic eruptions, explosions also generate Tsunamis.

Tsunamis generated by earthquakes

By far, the most destructive tsunamis are generated from large, shallow earthquakes with an epicenter or fault line near or on the ocean floor. These usually occur in regions of the earth characterized by tectonic seduction along tectonic plate boundaries. The high seismicity of such regions is caused by the collision of tectonic plates. When these plates move past each other, they cause large earthquakes, which tilt, offset, or displace large areas of the ocean floor from a few kilometers to as much as a 1,000 km or more. The sudden vertical displacements over such large areas, disturb the ocean's surface, displace water, and generate destructive tsunami waves.

To generate tsunamis, earthquakes must occur underneath or near the ocean, be large and create movements in the sea floor

The waves can travel great distances from the source region, spreading destruction along their path. For example, the Great 1960 Chilean tsunami was generated by a magnitude 9.5 earthquake that had a rupture zone of over 1,000 km. Its waves were destructive not only in Chile, but also as far away as Hawaii, Japan and elsewhere in the Pacific. It should be noted that not all earthquakes generate tsunamis. Usually, it takes an earthquake with a Richter magnitude exceeding 7.5 to produce a destructive tsunami.

Tsunamis generated by volcanic eruptions

Although relatively infrequent, violent volcanic eruptions represent also impulsive disturbances, which can displace a great volume of water and generate extremely destructive tsunami waves in the immediate source area.

According to this mechanism, waves may be generated by the sudden displacement of water caused by a volcanic explosion, by a volcano's slope failure, or more likely by a phreatomagmatic explosion and collapse/engulfment of the volcanic magmatic chambers. One of the largest and most destructive tsunamis ever recorded was generated in August 26, 1883 after the explosion and collapse of the volcano of Krakatoa (Krakatau), in Indonesia. This explosion generated waves that reached 135 feet, destroyed coastal towns and villages along the Sunda Strait in both the islands of Java and Sumatra, killing 36, 417 people. It is also believed that the destruction of the Minoan civilization in Greece was caused in 1490 B.C. by the explosion/collapse of the volcano of Santorin in the Aegean Sea.

Less frequently, tsunami waves can be generated from displacements of water resulting from rock falls, icefalls and sudden submarine landslides or slumps.

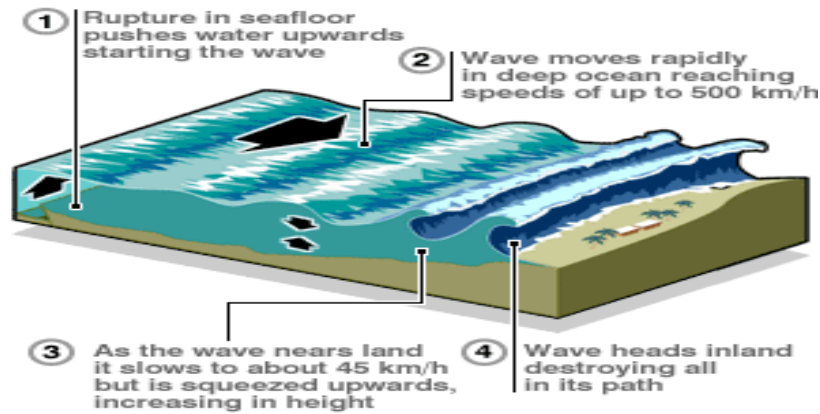
Tsunamis caused by asteroids, meteorites or man-made explosions

Fortunately, for mankind, it is indeed very rare for a meteorite or an asteroid to reach the earth. No asteroid has fallen on the earth within recorded history. Most meteorites burn as they reach the earth's atmosphere. However, large meteorites have hit the earth's surface in the distant past. This is indicated by large craters, which have been found in different parts of the earth. Also, it is possible that an asteroid may have fallen on the earth in prehistoric times - the last one some 65 million years ago during the Cretaceous period. Since evidence of the fall of meteorites and asteroids on earth exists, we must conclude that they have fallen also in the oceans and seas of the earth, particularly since four fifths of our planet is covered by water. The fall of meteorites or asteroids in the earth's oceans has the potential of generating tsunamis of cataclysmic proportions. Scientists studying this possibility have concluded that the impact of moderately large asteroid, 5-6 km in diameter, in the middle of the large ocean basin such as the Atlantic Ocean, would produce a tsunami that would travel all the way to the Appalachian Mountains in the upper two-thirds of the United States. On both sides of the Atlantic, coastal cities would be washed out by such a tsunami. An asteroid 5-6 kilometers in diameter impacting between the Hawaiian Islands and the West Coast of North America, would produce a tsunami which would wash out the coastal cities on the West coasts of Canada, U.S. and Mexico and would cover most of the inhabited coastal areas of the Hawaiian islands. Conceivably tsunami waves can also be generated from very large nuclear explosions. However, no tsunami of any significance has ever resulted from the testing of nuclear weapons in the past. Furthermore, such testing is presently prohibited by international treaty.

Tsunamigenesis

The mechanism how does tsunami energy travel across the ocean is called Tsunamigenesis. Once a tsunami has been generated, its energy is distributed throughout the water column, regardless of the ocean's depth. A tsunami is made up of a series of very long waves. The waves will travel outward on the surface of the ocean in all directions away from the source area, much like the ripples caused by throwing a rock into a pond. The wavelength of the tsunami waves and their period will depend on the generating mechanism and the dimensions of the source event.

If the tsunami is generated from a large earthquake over a large area, its initial wavelength and period will be greater. If the tsunami is caused by a local landslide, both its initial wavelength and period will be shorter. The period of the

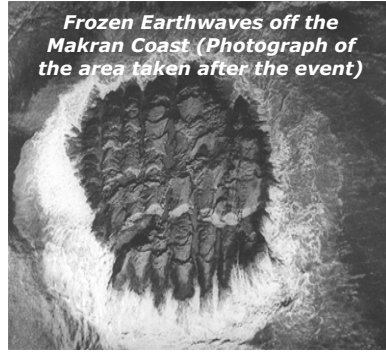


tsunami waves may range from 5 to 90 minutes. The wave crests of a tsunami can be a thousand km long, and from a few to a hundred kilometers or more apart as they travel across the ocean.

On the open ocean, the wavelength of a tsunami may be as much as two hundred kilometers, many times greater than the ocean depth, which is on the order of a few kilometers. In the deep ocean, the height of the tsunami from trough to crest may be only a few centimeters to a meter or more - again depending on the generating source. Tsunami waves in the deep ocean can travel at high speeds for long periods of time for distances of thousands of kilometers and lose very little energy in the process. The deeper the water, the greater the speed of tsunami waves will be. For example, at the deepest ocean depths the tsunami wave speed will be as much as 800 km/h, about the same as that of a jet aircraft. Since the average depth of the Pacific ocean is 4000 m (14,000 feet), tsunami wave speed will average about 200 m/s or over 700 km/h (500 mph). At such high speeds, a tsunami generated in Aleutian Islands may reach Hawaii in less than four and a half hours. In 1960, great tsunami waves generated in Chile reached Japan, more than 16,800 km away in less than 24 hours, killing hundreds of people.

History of Tsunamis in Pakistan/Arabian Sea

Though rare and relatively unheard of, tsunamis have struck the shores of Pakistan in the past. The deadliest was in 1945 which originated off the Mekran coast in Pakistan and the earliest known tsunami occurred in the Bay of Bengal in 1762, caused by an earthquake on Myanmar's, Arakan Coast. Detail of Tsunami occurred in 1945 is appended below.



The earthquake occurred at 21:56 UTC (02:56 PST). Its magnitude was 8.3 and was centred at;

87.1 kilometres SSW of Churi (Balochistan), Pakistan,
97.6 kilometres SSW of Pasni (Balochistan), Pakistan,
98.5 kilometres SE of Gwadar (Balochistan), Pakistan,
408 kilometres W of Karachi (Sindh), Pakistan

The tsunami reached a height of 40 feet in some Makran ports and caused great damage to the entire coastal region.

The fishing village of Khudi, some 30 miles west of Karachi, was completely obliterated. All the inhabitants and their huts were washed away.

Total causality was reported as around 4000.

The towns of Pasni and Ormara were badly affected. Both were reportedly "underwater" after the tsunami.

At Karachi, the tsunami arrived from the direction of Clifton and Ghizri. It ran along the oil installations at Keamari and flooded a couple of compounds. The waves were 6.5 feet high in Karachi.

Major Tsunamis in South Asia

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

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