

# Welcome to Vibrationdata

#### Acoustics • Shock • Vibration • Signal Processing

January 2005 Newsletter

### Megathrust Earthquake Disaster

We are very saddened to learn about the devastating earthquake that struck Indonesia's Sumatra Island, on December 26.

The confirmed death toll was 141,000 as of January 2, 2005, according to a CNN report. Most of the fatalities were due to tsunamis throughout the Indian Ocean. This number will increase as additional bodies are recovered. Furthermore, millions of homeless survivors are at risk of diseases such as cholera, pneumonia and malaria. Many of the refugees are suffering from lack of food and clean water.

The Sumatra earthquake was the largest in terms of magnitude since the 1964 Prince William Sound, Alaska earthquake.

The Sumatra earthquake was the most deadly natural disaster since China's Tangshan quake killed at least a quarter of a million in 1976.

Please make a generous donation to the Red Cross or to other disaster relief organizations.

Sincerely,

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Tom Irvine Email: tomirvine@aol.com



Northern Sumatra Earthquake and Tsunami

# Magnitude 9.0 - OFF THE WEST COAST OF NORTHERN SUMATRA

## 2004 December 26 00:58:53 UTC

#### Preliminary Earthquake Report

U.S. Geological Survey, National Earthquake Information Center World Data Center for Seismology, Deriver

A great earthquake occurred at 00:58:53 (UTC) on Sunday, December 26, 2004. The magnitude 9.0 event has been located OFF THE WEST COAST OF NORTHERN SUMATRA. (This event has been reviewed by a seismologist.)

#### Magnitude 9.0

Date-Time Sunday, December 26, 2004 at 00:58:53 (UTC) = Coordinated Universal Time Sunday, December 26, 2004 at 7:58:53 AM = local time at epicenter

Time of Earthquake in other Time Zones

- Location 3.317°N, 95.854°E
  - Depth 30 km (18.6 miles) set by location program

Region OFF THE WEST COAST OF NORTHERN SUMATRA

	<u>Distances</u>	250 km (155 miles) SSE of <b>Banda Aceh, Sumatra,</b> Indonesia 310 km (195 miles) W of Medan, Sumatra, Indonesia 1260 km (780 miles) SSW of <b>BANGKOK, Thailand</b> 1605 km (990 miles) NW of <b>JAKARTA, Java,</b> Indonesia
	Location Uncertainty	horizontal +/- 5.9 km (3.7 miles); depth fixed by location program
	Parameters	Nst=276, Nph=276, Dmin=654.7 km, Rmss=1.04 sec, Gp= 29°, M-type=moment magnitude (Mw), Version=T
A COLORING	Source	USGS NEIC (WDCS-D)
	Event ID	usslav

#### OFF W COAST OF NORTHERN SUMATRA

2004 12 26 00:58:53 UTC 3.32N 95.85E Depth: 30.0 km, Magnitude: 9.0

Earthquake Location

Major Tectonic Boundaries: Subduction Zones -purple, Ridges -red and Transform Faults -green

USGS National Earthquake Information Center



Map of INDONESIA



Courtesy of British Geological Survey

The epicenter of the 26 December 2004 earthquake is marked by the star. The 70 associated aftershocks are marked by red circles. These markers show the approximate length of the rupture zone. The red line indicates the plate boundary between the Indian and Asian plates.



Courtesy of British Geological Survey

This map shows the direction of motion of the Indian Plate relative to Eurasia. The length of the arrows shows the rate of convergence.



Death tolls as of January 1, 2005. Image courtesy of BBC.



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OFF WEST COAST OF NORTHERN SUMATRA 26 DEC 2004 00:58 UTC 9.0 MW

Seismograms of the earthquake as recorded on BGS seismometers in the UK.

#### Preliminary Earthquake Report

U.S. Geological Survey, National Earthquake Information Center World Data Center for Seismology, Denver

The devastating megathrust earthquake of December 26, 2004, occurred on the interface of the India and Burma plates and was caused by the release of stresses that develop as the India plate subducts beneath the overriding Burma plate. The India plate begins its descent into the mantle at the Sunda trench, which lies to the west of the earthquake's epicenter. The trench is the surface expression of the plate interface between the Australia and India plates, situated to the southwest of the trench, and the Burma and Sunda plates, situated to the northeast.

In the region of the earthquake, the India plate moves toward the northeast at a rate of about 6 cm/year relative to the Burma plate. This results in oblique convergence at the Sunda trench. The oblique motion is partitioned into thrust-faulting, which occurs on the plate-interface and which involves slip directed perpendicular to the trench, and strike-slip faulting, which occurs several hundred kilometers to the east of the trench and involves slip directed parallel to the trench. The December 26 earthquake occurred as the result of thrust-faulting.

Preliminary locations of larger aftershocks following the megathrust earthquake show that approximately 1200 km of the plate boundary slipped as a result of the earthquake. By comparison with other large megathrust earthquakes, the width of the causative fault-rupture was likely over one-hundred km. From the size of the earthquake, it is likely that the average displacement on the fault plane was about fifteen meters. The sea floor overlying the thrust fault would have been uplifted by several meters as a result of the earthquake. The above estimates of fault-dimensions and displacement will be refined in the near future as the result of detailed analyses of the earthquake waves.

The world's largest recorded earthquakes have all been megathrust events, occurring where one tectonic plate subducts beneath another. These include:

- 1. The magnitude 9.5 1960 Chile earthquake
- 2. The magnitude 9.2 1964 Prince William Sound, Alaska, earthquake
- 3. The magnitude 9.1 1957 Andreanof Islands, Alaska, earthquake
- 4. The magnitude 9.0 1952 Kamchatka earthquake

As with the recent event, megathrust earthquakes often generate large tsunamis that cause damage over a much wider area than is directly affected by ground shaking near the earthquake's rupture.

#### Tsunami Introduction by Tom Irvine

Tsunami is the Japanese word for "harbor wave." A tsunami may be generated by an underwater disturbance from a volcano, earthquake, or severe landslide. A large meteor impacting the ocean could also cause a tsunami.

Earthquakes are the primary source, however. A tsunami is also referred to as a "seismic sea wave."

The seafloor may experience an abrupt or pulsating displacement during an earthquake. This causes a vertical displacement in the water column above the seafloor. A tsunami is generated as the water is pulled back to its equilibrium condition by gravity. The potential energy of the water column is transformed to kinetic energy of the waves.

Tsunamis have extremely long periods, from 2 minutes to over one hour. A tsunami in the deep ocean may have a length of over 100 miles (160 km) from wave crest to crest. The wave may propagate as speeds up to 500 mph (800 km/hr).

In contrast, a typical wind-generated swell at a surf beach has a period of about 10 seconds and a wavelength of 500 feet (150 m).

The amplitude or height of the tsunami may only be a few feet over the deep ocean. The amplitude increase sharply as the wave reaches shallow zones near coastlines. The wave speed decreases, however.

The tsunami speed v is

$$v = \sqrt{gd}$$

where g is gravity and d is the depth.

The wavelength  $\lambda$  is

$$\lambda = vT$$

where T is the period.

The speed slows in shallow depths due to frictional effects between the water and the seafloor.

Most tsunamis do not create giant breaking waves on shore. Rather they generate fast tides that cause a rapid sea level rise, particularly as the tsunami reaches a shallow harbor.

The following images are courtesy of the USGS.



#### Panel 1—Initiation

The potential energy that results from pushing water above mean sea level is transferred to horizontal propagation of the tsunami wave (kinetic energy). For the case shown above, the earthquake rupture occurred at the base of the continental slope in relatively deep water. Situations can also arise where the earthquake rupture occurs beneath the continental shelf in much shallower water.

Note: In the figure the waves are greatly exaggerated compared to water depth. In the open ocean, the waves are at most, several meters high spread over many tens to hundreds of kilometers in length.



### Panel 2—Split

Within several minutes of the earthquake, the initial tsunami (Panel 1) is split into a tsunami that travels out to the deep ocean (distant tsunami) and another tsunami that travels towards the nearby coast (local tsunami). The height above mean sea level of the two oppositely traveling tsunamis is approximately half that of the original tsunami (Panel 1). (This is somewhat modified in three dimensions, but the same idea holds.) The speed at which both tsunamis travel varies as the square root of the water depth. Therefore the deep-ocean tsunami travels faster than the local tsunami near shore.



#### Panel 3--Amplification

Several things happen as the local tsunami travels over the continental slope. Most obvious is that the amplitude increases. In addition, the wavelength decreases. This results in steepening of the leading wave--an important control of wave run-up at the coast (next panel). Note also that the deep ocean tsunami has traveled much farther than the local tsunami because of the higher propagation speed. As the deep ocean tsunami approaches a distant shore, amplification and shortening of the wave will occur, just as with the local tsunami shown above.



### Panel 4—Run-up

Tsunamis continue after reaching land. After run-up, part of the tsunami energy is reflected back to the open ocean. In addition, a tsunami can generate a particular type of wave called edge waves that travel back-and forth, parallel to shore. These effects result in many arrivals of the tsunami at a particular point on the coast rather than a single wave suggested by Panel 3. The first run-up of a tsunami is often not the largest due to the complicated behavior of tsunami waves near the coast, emphasizing the importance of not returning to a beach several hours after a tsunami hits.

#### Sumatra Earthquake Tsunami



Tourists, fishermen, homes and cars were swept away by walls of water that propagated across the Bay of Bengal, generated by the magnitude 9.0 earthquake.

The tsunami that struck Sri Lanka had an amplitude of 30 feet (9.1 meters). Roland Buerk, a reporter in Unawatuna, Sri Lanka, wrote that he and his associates were swept along by the wave for "a few hundred meters, trying to dodge the motorcycles, refrigerators, cars and other debris that were coming with us."

The tsunami also struck Maldives, an archipelago of 1,190 low-lying coral islands, dotted across hundreds of miles of the Indian Ocean. The average height of these islands is 3 feet (1 meter). Waves swept completely across many of these islands. The waves extended over as much as half of Male, a relatively large island of 0.7 square miles pouring down the narrow, sandy streets and dashing against buildings including the president's office.

A British family filmed the tsunami coming ashore at Thailand's Phuket resort.





## Photo Gallery













REUTERS/Beawiharta, courtesy www.alertnet.org



M. Lakshman, AP Fishing boats sit on a pier after they were washed ashore in Chennai, India.

#### News Reports

BANGKOK, Thailand (AP) -- Knowledge of the ocean and its currents passed down from generation to generation of a group of Thai fishermen known as the Morgan sea gypsies saved an entire village from the Asian tsunami, a newspaper said Saturday.

By the time killer waves crashed over southern Thailand last Sunday the entire 181 population of their fishing village had fled to a temple in the mountains of South Surin Island, English language Thai daily The Nation reported.

"The elders told us that if the water recedes fast it will reappear in the same quantity in which it disappeared," 65-year-old village chief Sarmao Kathalay told the paper.

So while in some places along the southern coast, Thais headed to the beach when the sea drained out of beaches -- the first sign of the impending tsunami -to pick up fish left flapping on the sand, the gypsies headed for the hills.

Few people in Thailand have a closer relationship with the sea than the Morgan sea gypsies, who spend each monsoon season on their boats plying the waters of the Andaman Sea from India to Indonesia and back to Thailand.

Between April and December, they live in shelters on the shore surviving by catching shrimp and spear fishing. At boat launching festivals each May, they ask the sea for forgiveness.

#### Excerpts from:

#### Seeking Survivors on Swallowed Islands By Amitabh Bhattasali, BBC



- About 400 islands, 38 inhabited
  Islands are peaks of
- submerged mountain range • Indian territory, area of 8,249
- sq km • Population around 370,000,
- about 100,000 in Port Blair • Number of tribes, including
- Jarawas, Onges and Shompens

Giant tsunami waves struck the Andaman and Nicobar archipelago and devastated most of the southern islands.

Indian air force officers said that some of these islands like Katchall had simply vanished, no longer visible from the air.

"We can't find the islands from the coordinates we have," said one, who asked not to be identified.



Naval ships have been deployed as floating refugee camps

#### **Excerpts from:**

#### Deserted Aceh in Ruins By Jonathan Head BBC



It's New Year's Day and I'm in a town I know well from many, many visits in the past but today I hardly recognise it.

This is Banda Aceh, which six days ago bore the full brunt of the tsunamis that tore into this part of the island of Sumatra.

The damage is astounding. Just at the end of this road is a square I used to go to join hundreds of Acehnese families who would eat together in the evenings from different stalls selling food there.

That is completely destroyed and bizarrely there is an enormous wooden fishing boat that has been hurled into the centre of the square by the force of the waves, from the port which is at least a kilometre away. Statistics for Worldwide Earthquakes since 1900

Descriptor /	Average Frequency Per Year
Great	1
Major	18
Strong	120
Moderate	800
Light	6,200
Minor	49,000
Very minor	52,000
Very minor	416,000
	Descriptor         Great         Major         Strong         Moderate         Light         Minor         Very minor         Very minor

#### **USGS** Questions and Answers

#### Question: What effect did this earthquake have on the rotation of the earth?

**Answer:** Richard Gross at JPL has modeled the coseismic effect on the Earth's rotation of the December 26 earthquake in Indonesia by using the PREM model for the elastic properties of the Earth and the Harvard centroid-moment tensor solution for the source properties of the earthquake. The result is:

change in length of day: -2.676 microseconds polar motion excitation X : -0.670 milliarcseconds polar motion excitation Y: 0.475 milliarcseconds

Since the length of the day can be measured with an accuracy of about 20 microseconds, this model predicts that the change in the length-of-day caused by the earthquake is much too small to be observed. And, since the location of the earthquake was near the equator, this model predicts that the change in polar motion excitation is also rather small, being about 0.82 milliarcsecond in amplitude. Such a small change in polar motion excitation will also be difficult to detect.