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Earth's Dynamic Systems: Tsunamis

Waves of Destruction

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Contents

Introduction

Chapter 1: The Discovery of Tsunamis

Chapter 2: Understanding Tsunamis

Chapter 3: Key Characteristics of Tsunamis

Chapter 4: The Science Behind Tsunamis

Chapter 5: Observation and Measurement of Tsunamis

Chapter 6: Important Features of Tsunamis

Chapter 7: Tsunamis in Context

Chapter 8: Modern Understanding of Tsunamis

Chapter 9: Research and Exploration of Tsunamis

Chapter 10: Significant Discoveries About Tsunamis

Chapter 11: Challenges and Mysteries of Tsunamis

Chapter 12: Future Directions in Tsunamis Research

Chapter 13: Fun Facts and Trivia About Tsunamis

Chapter 14: Conclusion: The Significance of Tsunamis

Conclusion

This free sample contains the Introduction and Chapter 1. The complete book contains the full contents above.

Introduction

A tsunami ((t)soo-NAH-mee, (t)suu-; from Japanese: 津波, lit. 'harbour wave', pronounced [tsɯnami]) is a series of waves in a water body caused by the displacement of a large volume of water, generally in an ocean or a large lake. Earthquakes, volcanic eruptions, underwater explosions, landslides, glacier calvings, meteorite impacts and other disturbances above or below water all have the potential to generate a tsunami.

Unlike normal ocean waves, which are generated by wind, or tides, which are in turn generated by the gravitational pull of the Moon and the Sun, a tsunami is generated by the displacement of water from a large event. Tsunami waves do not resemble normal undersea currents or sea waves because their wavelength is far longer. Rather than appearing as a breaking wave, a tsunami may instead initially resemble a rapidly rising tide.

For this reason, it is often referred to as a tidal wave, although this usage is not favoured by the scientific community because it might give the false impression of a causal relationship between tides and tsunamis. Tsunamis generally consist of a series of waves, with periods ranging from minutes to hours, arriving in a so-called "wave train". Wave heights of tens of metres can be generated by large events.

Although the impact of tsunamis is limited to coastal areas, their destructive power can be enormous, and they can affect entire ocean basins. The 2004 Indian Ocean tsunami was among the deadliest natural disasters in human history, with at least 230,000 people killed or missing in 14 countries bordering the Indian Ocean.

The Ancient Greek historian Thucydides suggested in his 5th century BC History of the Peloponnesian War that tsunamis were related to submarine earthquakes, but the understanding of tsunamis remained slim until the 20th century, and much remains unknown. Major areas of current research include determining why some large earthquakes do not generate tsunamis while other smaller ones do. This ongoing research is designed to help accurately forecast the passage of tsunamis across oceans as well as how tsunami waves interact with shorelines.

Volcanic islands hold a quieter version of the same threat: flanks built of loose, poorly consolidated ash and rubble that can fail and slide seaward, and some edifices are thought to be developing the buried slip surfaces that would let an entire flank go at once.

What separates a genuine tsunami from any ordinary wave is its birth: a

lasting displacement of the whole water column, driven by an earthquake, a landslide, a volcanic blast, a calving glacier or a falling meteorite — never by wind pushing on the surface.

Chapter 1: The Discovery of Tsunamis

The term "tsunami" is a borrowing from the Japanese tsunami (津波), meaning 'harbour wave'. For the plural, one can either follow ordinary English practice and add an s, or use an invariable plural as in the Japanese. Most English speakers alter the word's initial /ts/ to an /s/ by dropping the "t," since English does not natively permit /ts/ at the beginning of words, though the original

Japanese pronunciation is /ts/.

The term has become commonly accepted in English, although its literal Japanese meaning is not necessarily descriptive of the waves, which do not occur only in harbours. Tsunamis are sometimes referred to as tidal waves. This once-popular term derives from the most common appearance of a tsunami, which is that of an extraordinarily high tidal bore.

Tsunamis and tides both produce waves of water that move inland, but in the case of a tsunami, the inland movement of water may be much greater, giving the impression of an incredibly high and forceful tide. In recent years, the term "tidal wave" has fallen out of favour, especially in the scientific community, because the causes of tsunamis have nothing to do with those of tides, which follow the tug of moon and sun rather than any displacement of water.

Although the meanings of "tidal" include "resembling" or "having the form or character of" tides, use of the term tidal wave is discouraged by geologists and oceanographers. The term seismic sea wave is also used to refer to the phenomenon because the waves most often are generated by seismic activity such as earthquakes. Prior to the rise of the use of the term tsunami in English, scientists generally encouraged the use of the term seismic sea wave rather than tidal wave.

However, like tidal wave, seismic sea wave is not a completely accurate term, as forces other than earthquakes—including underwater landslides, volcanic eruptions, underwater explosions, land or ice slumping into the ocean, meteorite impacts, and the weather when the atmospheric pressure changes very rapidly—can generate such waves by displacing water.

The use of the term tsunami for waves created by landslides entering bodies of water has become internationally widespread in both scientific and popular literature, although such waves are distinct in origin from large waves generated by earthquakes. This distinction sometimes leads to the use of other terms for landslide-generated waves, including landslide- triggered tsunami, displacement wave, non-seismic wave, impact wave, and, simply, giant wave. A tsunami which cannot be linked to an earthquake is sometimes

termed an "orphan tsunami".

This may happen in the case of tsunamis caused in the distant past, before international communications, by earthquakes far away, such as a tsunami in Japan caused by an earthquake in the Americas. Japan has the longest recorded history of tsunamis. As early as 426 BC the Greek historian Thucydides inquired in his book History of the Peloponnesian War about the causes of tsunami, and was the first to argue that ocean earthquakes must be the cause.

The oldest human record of a tsunami dates back to 479 BC, in the Greek colony of Potidaea, thought to be triggered by an earthquake. The tsunami may have saved the colony from an invasion by the Achaemenid Empire. The cause, in my opinion, of this phenomenon must be sought in the earthquake. At the point where its shock has been the most violent the sea is driven back, and suddenly recoiling with redoubled force, causes the inundation.

Without an earthquake I do not see how such an accident could happen. The Roman historian Ammianus Marcellinus (Res Gestae 26.10.15-19) described the typical sequence of a tsunami, including an incipient earthquake, the sudden retreat of the sea and a following gigantic wave, after the 365 AD tsunami devastated Alexandria. Tsunamis are an often underestimated hazard in the Mediterranean Sea and parts of Europe.

Of historical and current (with regard to risk assumptions) importance are the 1755 Lisbon earthquake and tsunami, the 1783 Calabrian earthquakes, each causing several tens of thousands of deaths and the 1908 Messina earthquake and tsunami. The tsunami claimed more than 123,000 lives in Sicily and Calabria and is among the deadliest natural disasters in modern Europe. The Storegga Slide in the Norwegian Sea and some examples of tsunamis affecting the British Isles refer to landslide and meteotsunamis, predominantly and less to earthquake-induced waves.

The destruction caused by the 2004 Indian Ocean earthquake and tsunami event mark it as the most devastating of its kind in modern times, killing around 230,000 people. The Sumatran region is also accustomed to tsunamis, due to earthquakes of varying magnitudes that occur regularly off the coast of the island. The principal generation mechanism of a tsunami is the displacement of a substantial volume of water or perturbation of the sea.

This displacement of water is usually caused by earthquakes, but can also be attributed to landslides, volcanic eruptions, glacier calvings or more rarely by meteorites and nuclear tests. However, the possibility of a meteorite causing a tsunami is debated. Tsunamis can be generated when the sea floor abruptly

deforms and vertically displaces the overlying water.

Abe introduced the tsunami magnitude scale

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ABOUT THE AUTHOR

Aira Astralis is a science writer specializing in astronomy and space exploration. Her work spans the full breadth of humanity's relationship with the cosmos -- from the earliest naked-eye observations to the engineering marvels of modern space missions.

Her books are built on a foundation of primary sources: peer-reviewed research, mission archives, and direct engagement with the scientific community. She writes for readers who want to understand not just what we know about the universe, but how we came to know it.

She believes that the most important frontier is not out there but in the gap between what scientists discover and what the public understands. Her books exist to close that gap.