Geography

HOMEWORK

9A Ten Terrible Tectonic Events

Name

Tutor Group

Teacher

The homework booklet contains essential reading on

- **Ten terrible tectonic events** through history *plus* planning for your **Indonesia tectonics essay.**

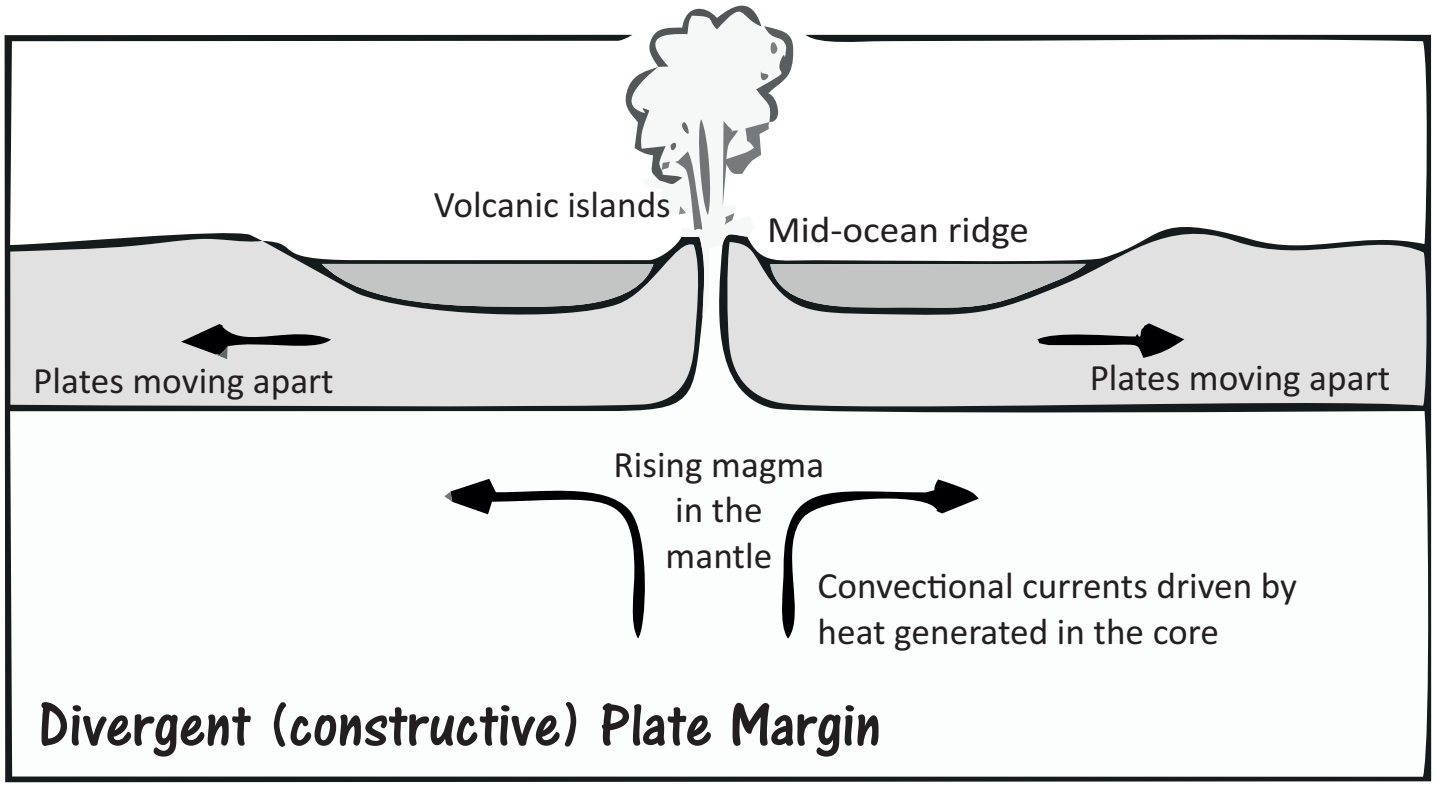
Your homework will be set and reviewed on ☑

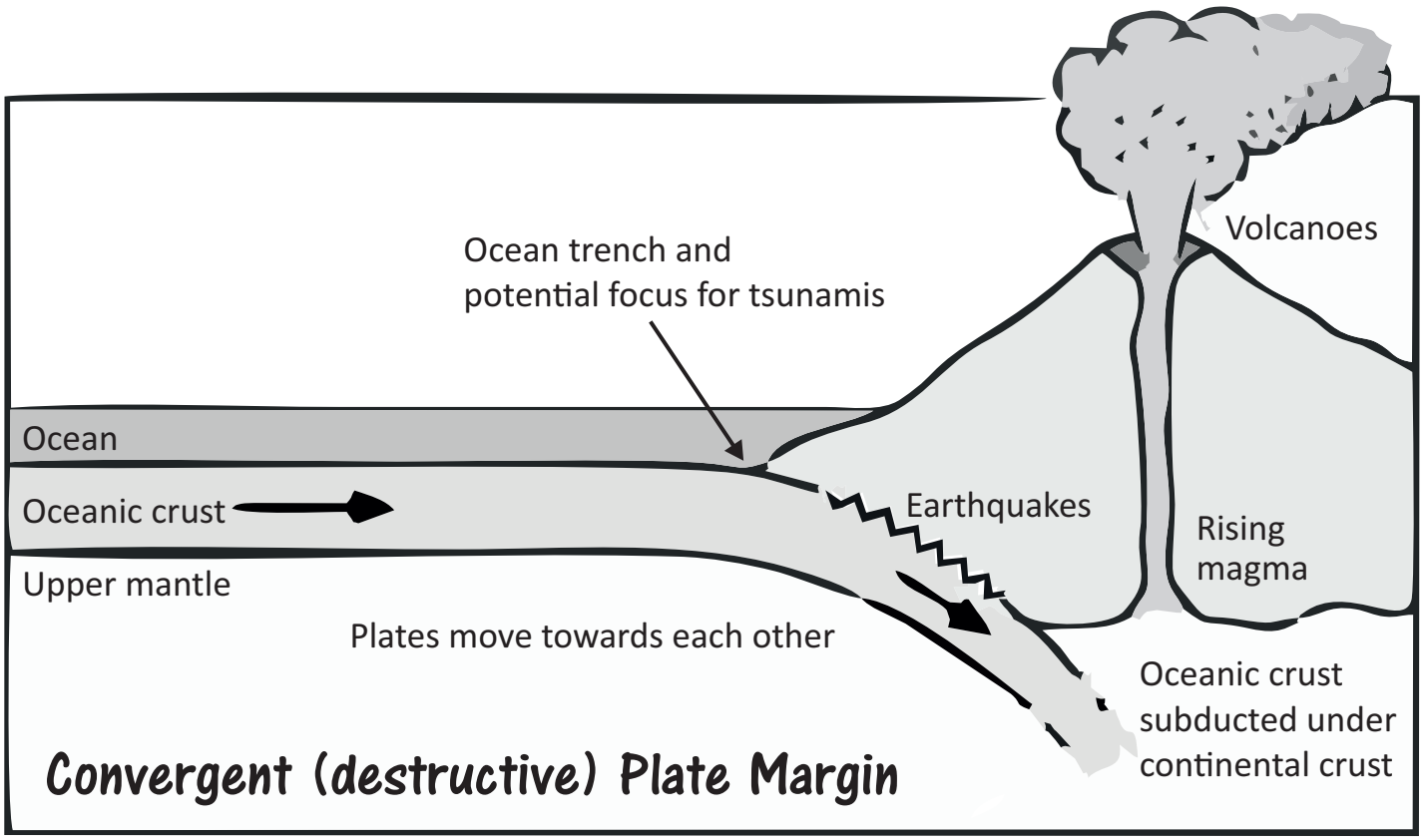
☐ Monday ☐ Tuesday ☐ Wednesday

☐ Thursday ☐ Friday

People ● Place ● Pattern ● Process

Two tectonic plate margins





In this homework booklet you will read about ten dangerous and damaging tectonic events. Each week's reading will be followed up with a quick knowledge text in class.

Introduction: Ten Terrible Tectonic Events, Part 1.

How do you even begin to choose the 'top ten' tectonic events? Volcanic eruptions and earthquakes have been happening throughout the 4.6 billion years of Earth's history.

Through much of geological time our planet has evolved and changed gradually through slow acting processes of erosion, transportation and deposition. In contrast the immense forces involved in tectonic plate movement can bring about rapid and significant change in a geological instant.

These events have fascinated, challenged and even supported people throughout human history. Initially attributed to a power of God or the Gods, today geography and science have developed theories which provide a greater understanding of the causal mechanisms. This understanding can help us to mitigate (minimise) their dangers but can never eliminate the risk entirely.

It is estimated that by 2025 six hundred million people will be living in tectonically active areas. Do the advantages outweigh the disadvantages? Most volcanoes and earthquake zones are safe for long periods between eruptions or earthquakes.

#10 Mount Tambora, Indonesia. 8°15'0"S, 118°0'0"E

Largest volcanic eruption ever recorded by humans. Mount Tambora, on the Indonesian island of Sumbawa, erupted in April 1815 with devastating effect. **It was the largest eruption ever recorded by humans** and had a Volcanic Explosivity Index (VEI) of 7. **The eruption was heard over 1,200 miles away!**

Mount Tambora is just one of over 120 active volcanoes in Indonesia. It is a composite volcano formed at a destructive (convergent) plate boundary. Here the Australian plate is subducted beneath the Sunda plate.

Tambora's eruption was one of the most deadly in recent history, causing the deaths of more than 71,000 people. The initial death toll was probably close to 10,000, people killed by pyroclastic flows and ash. However, the majority of the deaths were not 'local' to the volcano. They were attributed to the famine and disease that spread across Europe and North America as a result of the eruption.

1816 was named 'the Year without a summer'. As huge amounts of ash were ejected into the high atmosphere from the eruption they spread around the globe. The ash, along with sulphur dioxide gas, reflected some of the Sun's radiation, cooling global temperatures by between 0.4°C and 0.7°C.

#9 Mount Vesuvius, Italy. 40°49'0"N, 14°26'0"E

The most active volcano on European mainland. Whilst Iceland has the nearest active volcanoes to the UK, Vesuvius represents the closest active volcano to the UK on **mainland** Europe. Mount Etna is the most active volcano in Europe but it is located on the island of Sicily not the continental mainland. **Vesuvius is a composite volcano formed as the African Plate is forced beneath the Eurasian Plate at a destructive or 'convergent' plate boundary.**

Vesuvius erupts, March 17-24, 1944.

Vesuvius remains active to this day, although there have be no significant eruptions recorded since 1944. During that eruption the ash cloud disrupted the advance of American troops up the Italian peninsular. **Vesuvius is best known for its eruption in AD 79.** This violent eruption is famed for the perfectly preserved body casts of the people killed instantly by pyroclastic flows and then preserved in the layers of ash that fell following the eruption. Approximately 16,000 people lost their lives in the two nearby cities of Pompeii and Herculaneum.

A surviving eye witness, a Roman historian called Pliny the Younger now lends his name to the type of eruption witnessed that day. A 'Plinean' eruption is characterised by a large volume, violent eruption that produces quickly expanding clouds of rock, ash and gases rising many kilometres into the atmosphere.

Today, Vesuvius is regarded as one of the potentially most dangerous volcanoes in the world. A very large population of three million people live nearby, in and around Naples. This area is one of the most densely populated volcanic regions in the world with few roads and railways on which to evacuate such a large number of people. Volcanologists fear that there may simply be not enough time to evacuate the whole city in light of Vesuvius' potential for violent and explosive eruptions.

#8 Mount Pinatubo, Philippines. 15°81'30"N, 120°21'0"E

Best predicted and managed major volcanic eruption. A more recent Plinean eruption occurred on 15th June 1991 at Mount Pinatubo in the Philippines. **Here, as two plates collide, the oceanic Philippines plate is subducted beneath the less dense, continental Eurasian Plate. There is a large build-up of both magma and pressure, resulting in explosive eruptions.**

Pinatubu ash burys palm trees

Despite the scale of the 1991 eruption the death toll was relatively low: only 847 people died. The main cause of death was not the eruption itself but injuries from roofs collapsing under the weight of the ash. In addition, mud flows of ash and water called lahars ash swept away villages when Typhoon Yunga, a tropical storm, brought torrential rainfall to steep valley slopes. At the time the Philippines was a classified as a Low Income Developing Country with a Human Development Index of only 0.598, ranking it as 158th in the global development league table. While an estimated 1.2 million people lost their homes, how was the death toll kept so low?

The answer lies thousands of miles away in the USA. In May 1980 a similar volcano, Mount St Helens, had erupted in Washington State. While closely monitored the volcano was in a remote rural location. Despite this, 57 people died in the eruption. Geographers and volcanologists learnt a lot from Mount St Helens and the theories explaining volcanic eruptions were becoming more detailed.

Volcanologists learned how to 'read the signs' that an eruption was imminent. **The lessons gained from studying Mount St Helens, alongside the presence of a huge US Airbase near to Pinatubo, ensured that the volcano was monitored closely from for over two months prior to the June eruption.** As a result over 75,000 people were evacuated. The United States Geological Service aided by a fleet of US Army helicopters helped save a large number of lives.

Despite the evacuation there were still significant after effects from the eruption. Farmland was buried in ash and unusable for years, while it was estimated that over 650,000 local people lost their jobs as a result of eruption disruption. **Globally, the ash from the eruption spread through the stratosphere blocking sunlight around the world and lowering global temperatures by 0.5°C.**

Homework Nº2: Set date Check date

Learning about the meaning and spelling of key plate tectonics words.

For **Homework 2** you must read the following key words and definitions and practise the spelling. You must be ready to spell these words and remember what they mean for next week's homework check.

Practise the spellings on the next page. Fold this page in half along the dotted line to hide the words while you spell them.

Plate tectonics (plate tec-ton-ics)	Theory concerning the structure and processes of the Earth which explains the configuration of the continents and the location of earthquakes and volcanic activity.
Tectonic plate (tec-ton-ic plate)	Very large section of the Earth's crust.
Subduction zone (sub-duc-tion zone)	Zone on the Earth's surface where oceanic crust is pushed beneath continental crust, creating volcanoes and causing earthquakes.
Magma (mag-ma)	Molten rock and gases, rising from the mantle into the crust, released as lava at the surface.
Volcano (vol-ca-no)	A vent in the Earth's crust where magma escapes as lava and ash to form a mountain.
Epicentre (ep-i-cent-re)	The point on the Earth's surface directly above the focus of an earthquake.
Focus (fo-cus)	The actual point within the crust where built-up tension and energy is released in an earthquake.
Seismic wave (seis-mic wave)	The energy waves released by an earthquake which travel outwards from the focus.
Seismograph (seis-mo-graph)	Also known as a seismometer, an instrument used to detect and record seismic waves.
Tsunami (tsu-na-mi)	A large wave, or waves, resulting from an undersea earthquake or eruption which displaces the water above.

Practise your spellings

Practise your spellings on this page. Spelling the word on the line above the definition and then check. If you get it wrong you can try again.

Theory concerning the Earth which explains earthquakes and volcanic activity.

Very large section of the Earth's crust.

Zone where oceanic crust is pushed under continental crust.

Molten rock and gases, rising from the mantle into the crust.

A vent in the Earth’s crust where lava and ash form a mountain.

The point on the Earth’s surface directly above the focus of an earthquake.

The point within the crust where energy is released during an earthquake.

The energy waves froman earthquake which travel outwards from the focus.

An instrument used to detect and record seismic waves.

A large wave, or waves, resulting from an undersea earthquake or eruption.

Ten Terrible Tectonic Events, Part 2.

#7 Valdivia, Chile. The Great Chilean Earthquake 38°14'24"S, 73°3'0"W

Most powerful earthquake in recorded history. This earthquake shook Chile on May 22nd 1960. It is estimated to have been around 9.5 on the Richter Scale, releasing energy equivalent to more than 25,000 nuclear bombs in just 10 minutes of shaking. T**he quake was caused by a 'mega thrust', a release of energy as the Nazca Plate was forced beneath the South American Plate at the destructive (convergent) plate boundary.** Over 1,000km of the boundary moved during the event. The epicentre was approximately 570 kilometres south of the Chilean capital, Santiago, and was named after the city most affected, Valdivia.

For such a large magnitude earthquake, the death toll appears to be relatively small, estimated at less than 7,000. This has been attributed to the relatively remote and rural nature of the surrounding area, combined with the well-planned and strict building regulations in place for such a tectonically active region. Nonetheless, some two million people were made homeless and the economic impact was significant with damage estimated at over $2 billion.

The quake triggered a number of associated hazards including landslides on the steep Andean hills and tsunamis that spread along the Chilean coastline. These tidal waves reached across the Pacific Ocean to Japan, New Zealand and Hawaii. There were 61 reported deaths in the coastal town of Hilo as tsunami the struck the coastline of Hawaii over 10,000km away.

#6 Port Au Prince earthquake, Haiti. 18°27'36"N, 72°31'48"W

Most deadly earthquake in modern times. It is widely accepted that the most deadly earthquake in human history occurred in China in 1556, when it is estimated that some 820,000 people may have died. However, it is difficult to quantify accurately because of the passage of time and lack of evidence.

In more recent times, **the 2010 Haiti earthquake is estimated to have killed up to 316,000 people**, although some suspect that this figure was inflated by the Haitian government. **Striking in the afternoon of the 12th January 2010, the quake measured 7 on the Richter Scale** and was focussed on the complex tectonic setting under the island of Hispaniola. **The source of the tension in the crust is the transform boundary, where the North American plate slides alongside and against the Caribbean plate.** The epicentre was on a fault line running off this main plate boundary. Here the two sides of the fault move past each other in an east-west direction, known as a strike/slip fault.

Why was this quake so deadly? The focus was shallow and epicentre just 10 miles southwest of the capital city, Port Au Prince. The earthquake's seismic waves combined together to devastate an area with a large and densely concentrated population. It is estimated that over 3 million people were affected by the quake.

Haiti is the poorest country in the Western Hemisphere. It has a HDI of 0.404 placing it 145th in the world. **This means that Haiti's people are more vulnerable to the effects of natural disasters.** They have limited funds to plan and prepare for such events. Many of the buildings that collapsed were poorly constructed concrete buildings. However, many were made weaker by even more poorly enforced building regulations.

Finally, the response to the earthquake was challenging as many of the nation's communication links were destroyed. The infrastructure of an already weak government was devastated. Over a year after the event, more than 1 million people remained in refugee camps. This led to a spread of cholera and further deaths on top of the already considerable death toll from the earthquake itself.

#5 Gorkha earthquake, Nepal. 28°13'48"N, 84°43'51"E

Major earthquake strikes Nepal. On Saturday 25th April 2015, the largest earthquake to hit Nepal for over 80 years struck. Measuring 7.8 on the Richter scale the quake affected a large area up to 100km radius from the epicentre which was centred on the Gorkha district, northwest of the capital Kathmandu.

Earthquakes in Nepal are caused by the collision of the Eurasian and Indo-Australian Plates. They move together at a rate of 45mm a year. **This may not seem like much, but this movement has been responsible for building the Himalayas; the highest and largest mountain range on the planet.**

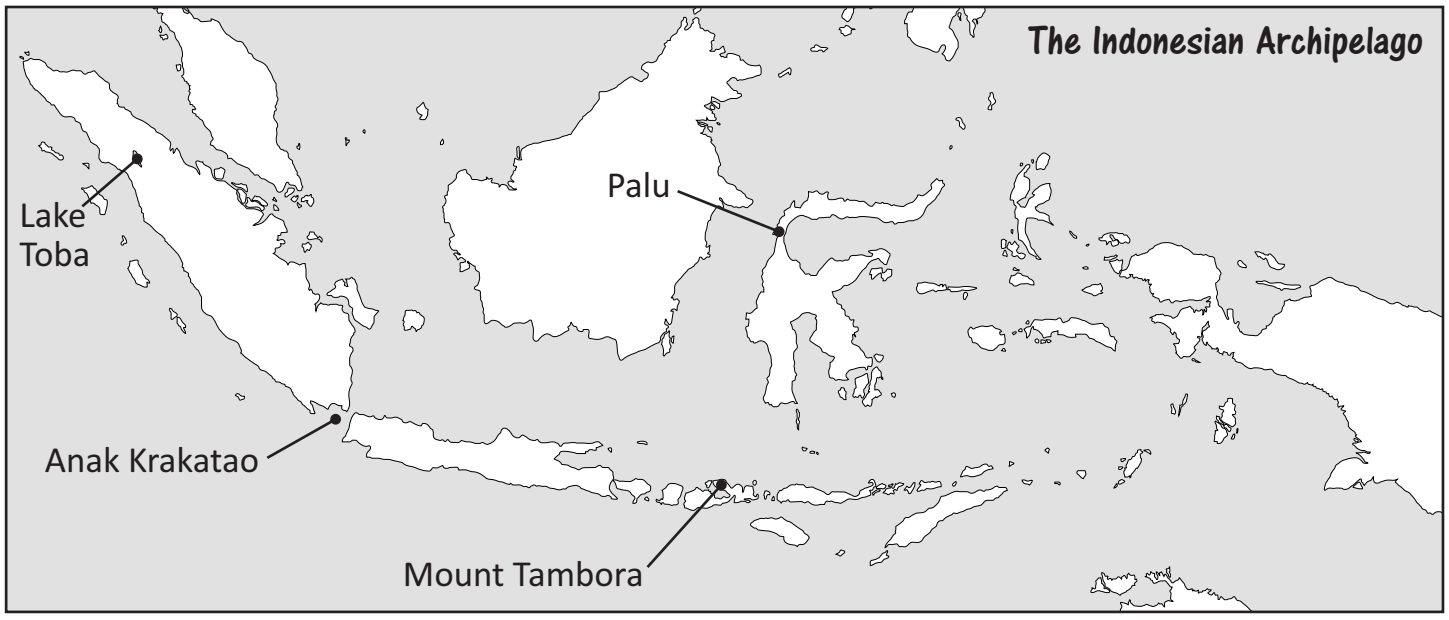
As the earth shook, villages were flattened and historic buildings in Kathmandu destroyed or severely damaged. **Nearly 9,000 people lost their lives and over three million were left homeless.** Despite the loss of thousands of Nepalese lives much of the worldwide news coverage focussed on the 8 people who died at Everest base-camp. They were killed in an avalanche triggered by the earthquake. The impact were worsened by a large number of aftershocks and exposed the extreme poverty of the worst hit areas. Accessing remote rural areas were extremely challenging as a result of landslides destroying many mountain roads. The recovery was slow and difficult despite aid from the global community. **The damage caused by the Gorkha quake was estimated to be in the region of $10 billion, approximately 50% of the entire annual GDP of Nepal.**

Ten Terrible Tectonic Events, Part 3.
#4 Krakatoa and Anak Krakatao, Indonesia. 6°6'7"S, 105°25'23"E

Volcanic eruptions and tsunamis. In August 1883, the Indonesian volcanic island of Krakatoa erupted. **The eruption was so explosive that the eruption was heard in Perth, Australia over 2,800 miles away!** In Darwin, Northern Australia, the British naval commander mobilised the fleet believing the explosions were from pirates were attacking ships along the coast. An estimated 36,000 deaths were attributed to the eruption. **Most were killed by a tsunami which swept away coastal villages on the islands of Java and Sumatra. The tsunami was triggered as the flanks of the volcano collapsed into the sea. 165 coastal villages were destroyed.** A Dutch naval vessel was carried inland by the tsunami and deposited on a hillside five kilometres from the shore.

Krakatoa lies along the Pacific 'Ring of Fire' and the volcanic activity here is caused by the Indo-Australian Plate being forced beneath the Eurasian Plate. **Not only was the island of Krakatoa almost completely destroyed but the eruption released huge amounts of ash and sulphur dioxide gas in to the atmosphere. This reduced global temperatures by 1°C over the next 5 years.**

Today, the volcano remains active with smoke regularly rising from a new volcanic cone. This rose from the depths after the original island was all but destroyed. The recent eruption of 'Anak Krakatao' (Child of Krakatoa) in December 2018 mirrored the 1883 event, albeit without such a terrible death toll. During the eruption much of Anak Krakatao collapsed into the sea creating tsunamis up to 5 metres in height. **Over 400 people were killed and 14,000 wounded as these tsunamis struck along hundreds of kilometres of the Indonesian coastline.**



#3 Indian Ocean tsunami. 3°18'57"N, 95°51'14"E

The Boxing Day Tsunami. On December 26th 2005 a major earthquake measuring 9.1 on the Richter Scale struck off the western coastline of the Indonesian island of Sumatra. **This earthquake ruptured 1,000 kilometres of the fault where the Indo-Australian Plate is subducted beneath the Eurasian Plate.** The quake caused buildings to collapse in northern Sumatra but it was the resulting tsunami which caused the most devastation and loss of life. The Pacific Ocean has long had a tsunami warning system in place but the Indian Ocean had no such system in 2004. Shocking footage captured on mobile phones showed the sheer scale of the disaster, as huge waves rushed into coastal towns and tourist resorts.

Destruction in Banda Aceh

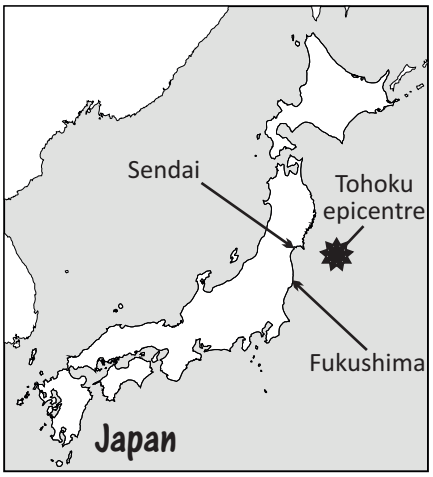
Fourteen countries were struck by the tsunami. The largest waves were up to 25m high when they struck the nearest coastline Sumatra reaching the northern city of Banda Aceh within 20 minutes of the initial quake. The result was almost total devastation. In the open ocean the tsunami waves were travelling at over 800 kilometres per hour reaching Thailand within an hour and then spreading outwards past the Andaman Islands to devastate the coast of Myanmar, Sri Lanka and India. **Up to 10 hours after the initial earthquake the tidal waves had spread over 5,000 km to strike the east coast of Africa, causing hundreds of deaths in Somalia as well as loss of life in Kenya, Tanzania and South Africa.**

Due to the scale of devastation during this event, it proved almost impossible to calculate an accurate death toll. **Estimates run between 280,000 and 350,000.** The majority of those were in Indonesia, in the northern provinces of Sumatra. **More than 1.7 million people were displaced.** The economic impact was huge with the coastal fishing villages, prawn farms and tourist industries destroyed.

International offers of support and aid were swift, and in many cases effective. **Some good has come from bad and as a direct result of the disaster, a tsunami early warning system was established in the Indian Ocean and tsunami training and escape routes planned for coastal villages.** However, in September 2018 another tsunami stuck the Indonesian island of Sulawesi, killing 4,300 people in the coastal town of Palu. Another 10,000 were injured and 200,000 people made homeless. Subsequent investigations showed that the local tsunami warning system had failed due to lack of regular maintenance.

Ten Terrible Tectonic Events, Part 4.

#2 Tohoku earthquake and tsunami, Japan. 38°19'19"N, 142°22'8"E



The most expensive natural disaster ever. On March 11th 2011 Japan experienced the largest earthquake the country had ever recorded, reaching 9 on the Richter Scale. **Japan is at a complex plate boundary, where three plates, the Eurasian, Pacific and Philippines all meet.** It is a destructive (collision) boundary and has many fault lines running through and from it. As such, it experiences 30% of all the world's earthquakes every year. This experience, combined with the fact that Japan is an Advanced Country with a very high HDI of 0.909 (19th out of 189 countries) would suggest that perhaps, Japan would be well placed to have the capacity to cope with such a major event. **The country is home to some of the most advanced tectonic scientists on the planet.**

The death toll was relatively low when compared to the other events we have looked at with only 15, 846 deaths. The authorities and Japanese population are well trained to deal with issues caused by natural hazards, buildings are built to withstand major earthquakes and the Japanese Meteorological Agency, correctly measured the quake, predicted an ensuing tsunami and issued effective warnings, all of which minimised the initial death toll.

Despite approximately 40% of the Japanese coastline having tsunami walls (some up to 10m tall) in place, the tsunami breached these defences. In some places water reached up to 9 kilometres inland. The worst affected area, the city of Sendai, was almost totally destroyed. **Approximately 130,000 buildings were destroyed along the east coast.**

Perhaps the most worrying impact was the partial meltdown of the Fukushima Daiichi nuclear power station. An area of 20 kilometres around the station had to be evacuated due to concerns about radioactivity. This exclusion zone may remain in place for many decades. Japan immediately closed another ageing reactor over tsunami and earthquake safety. Meanwhile, thousands of miles away, Germany responded by announcing a phasing out of their own nuclear power plants.

The World Bank estimated the total costs of the earthquake and tsunami at $235 billion. Despite this, Japan recovered relatively quickly and remains a world economic superpower.

#1, Lake Toba, Northern Sumatra, Indonesia. 2°40'N 98°50'E

There are approximately twenty potential 'super-volcanoes' around the world, with perhaps the most famous being Yellowstone in the USA. There have been an estimated 42 'super' eruptions in the last 36 million years! To be classed as a 'super-volcano', eruptions must reach 8 or more on the Volcanic Explosivity Index and release over 1,000km^3 of tephra (ash and broken rock) into the atmosphere.

The most recent 'super-eruption' happened at Taupo in New Zealand 26,000 years ago. The Taupo volcano has erupted many times since but not on the scale of the super-eruption. That eruption created the caldera which is now filled with water as Lake Taupo. With New Zealand isolated from other landmasses and with no human population, it is hard to estimate the significance of the eruption. However, parts of the central North Island were covered with up to 200m of ash so the eruption would have been devastating for New Zealand wildlife.

Yellowstone in the USA has had three known eruptions: 2.1 million, 1.3 million and 640,000 years ago. It has formed at a 'hotspot' over a rising magma plume that remains stationary whilst the North American plate moves slowly across it.

The first eruption you read about in this booklet, Tambora, was close to a super eruption. Super-eruptions can cause significant local damage and can have a dramatic impact on global temperatures. **As we now we have a better understanding of tectonics and the forces involved, volcanoes like Yellowstone is closely monitored.** We could not prevent a super eruption but we can look to predict them and prepare for the disruption they may cause. However, we cannot know the extent of their impacts in our modern globalised world.

We do know that one super-volcano in particular has had a significant impact on human evolution. Lake Toba, on the Indonesian island of Sumatra, is the world's largest volcanic lake, stretching 100km from north to south and 30km east to west. **The crater was created by a super-eruption some 74,000 years ago.** So big was the eruption that is covered the whole of South East Asia with up to 15cm of ash. As ash blanketed the planet, global temperatures fell by an average of 5°C. In higher latitude temperatures fell by as much as 15°C. Already in a glacial 'ice age', Europe was plunged into a three year long icy winter. **Across the globe, the population of humans was reduced to between 3,000 to 10,000. Those living in northern latitudes were reduced to perhaps as few as 20.** It was those few survivors who became the ancestors of all white 'Caucasian' humans, explaining the lack of genetic diversity within this sub-section of the human race.