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91191



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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Earth and Space Science 2025

91191 Demonstrate understanding of the causes of extreme Earth events in New Zealand

Credits: Four

Achievement	Achievement with Merit	Achievement with Excellence
Demonstrate understanding of the causes of extreme Earth events in New Zealand.	Demonstrate in-depth understanding of the causes of extreme Earth events in New Zealand.	Demonstrate comprehensive understanding of the causes of extreme Earth events in New Zealand.

Check that the National Student Number (NSN) on your admission slip is the same as the number at the top of this page.

You should attempt ALL the questions in this booklet.

If you need more room for any answer, use the extra space provided at the back of this booklet.

Check that this booklet has pages 2–16 in the correct order and that none of these pages is blank.

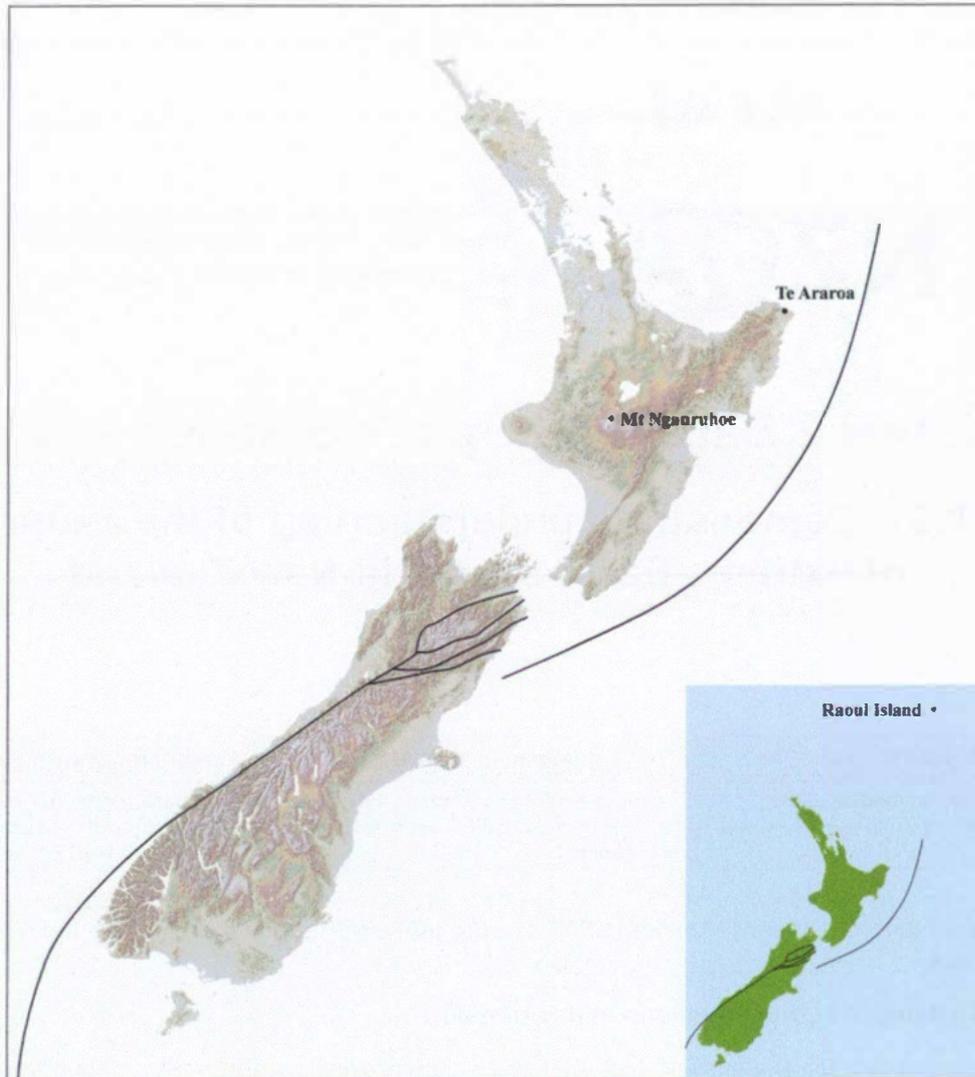
Do not write in any cross-hatched area (X/X/X). This area will be cut off when the booklet is marked.

YOU MUST HAND THIS BOOKLET TO THE SUPERVISOR AT THE END OF THE EXAMINATION.

Achievement

TOTAL 10

Regional map showing locations referred to in this paper



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The assessment begins on the following page.**

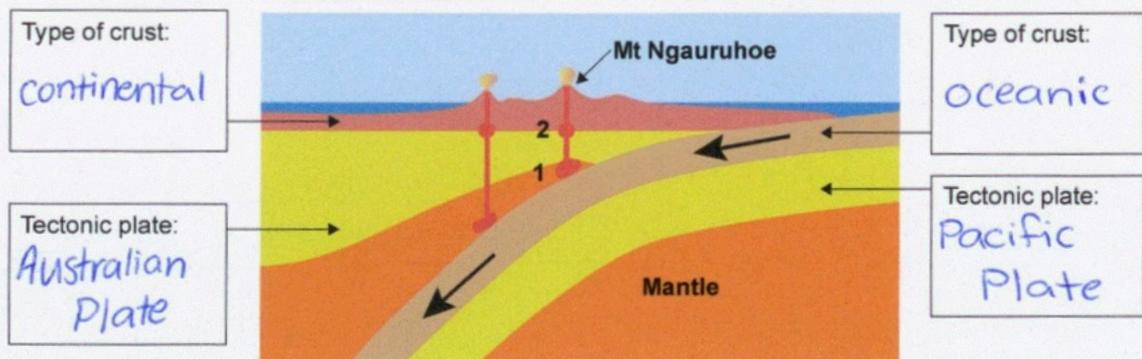
QUESTION ONE: MT NGAURUHOE

Mt Ngauruhoe is the youngest, largest, and most active cone of the much larger Tongariro volcanic complex in the central North Island of New Zealand.

Mt Ngauruhoe formed approximately 7000 years ago, and is an andesitic stratovolcano.

More than 60 eruptions have been recorded since written records began in 1839; many of these were ash eruptions, while some have been lava flows, with the last occurring in 1975.

- (a) Label the diagram to name the tectonic plates involved in this area of the North Island and identify the type of crust (continental or oceanic).



- (b) Explain, in detail, how tectonic processes led to the formation of andesitic magma.

In your answer you should consider:

- the map on page 2
- the labelled diagram in part (a)
- the key tectonic processes involved at 1 and 2 on the diagram above.

The two tectonic plates, Pacific and Australian, meet at a convergent plate boundary in the North Island of New Zealand. This means that the plates are being pushed together, causing the more dense oceanic plate (Pacific) to subduct under the Australian plate. Subduction of the Pacific plate allows magma from the mantle under the

Australian plate to rise closer to the surface or crust of the earth. This creates a hot spot underneath the crust.

Pressure from the movement of tectonic plates can cause cracks in the crust that allow magma to seep up from the mantle into the crust. There, the magma is stored in magma chambers until enough pressure builds up to cause an eruption.

The magma beneath Mount Ngauruhoe sits above the subducting Pacific plate, as shown in the diagram. Because it is closer to the crust and further away from the hot core of the earth, the magma is able to cool. As it's nearer to the crust, it is also exposed to the rocks that remain hard and cold that mixes with the magma making it thicker and more prone to trapping gases in it. This forms andesitic magma due to the temperature and viscosity.

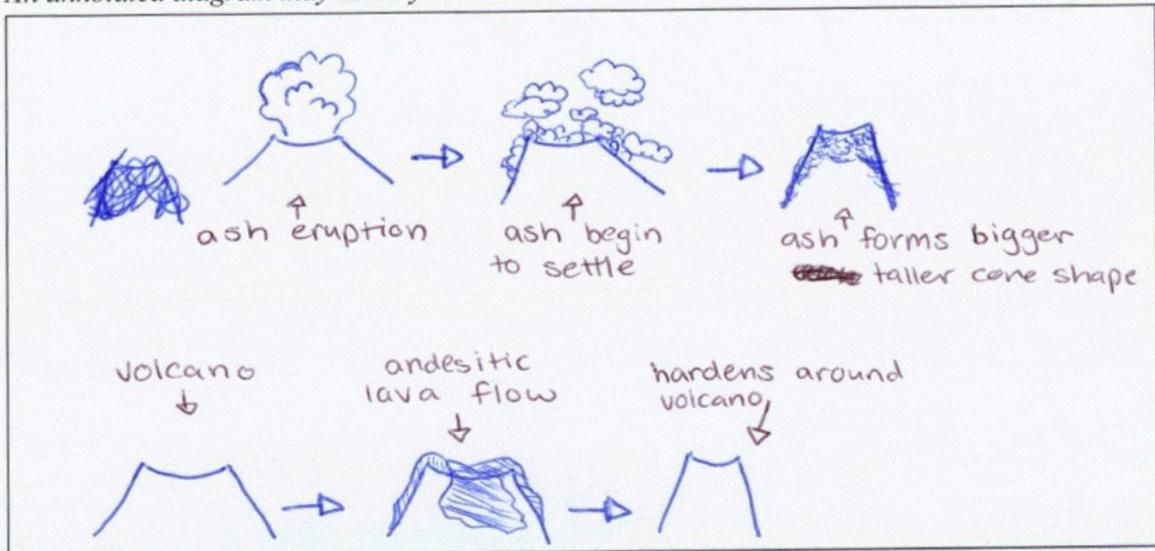
(c) Mt Ngauruhoe is an andesitic stratovolcano.

Explain, in detail, how andesitic magma leads to the formation of a stratovolcano.

In your answer you should consider:

- the characteristics of andesitic magma
- the type of eruptive products produced by Mt Ngauruhoe
- how layering and magma composition link to the shape of Mt Ngauruhoe.

An annotated diagram may assist your answer.



Mt Ngauruhoe is andesitic, and has had many ash eruptions with a few lava flows between 1839 and 1975. These eruptions led to the formation of a stratovolcano. The ash eruptions caused by high pressure forced hot ash into the air with explosive power. Once the ash begins to cool and settle, it rests on and around the volcano, adding to the shape and structure. The lava flows are thick and slow moving because of the viscosity. Andesitic magma has a medium amount of rock in it creating a thicker lava flow. This means that the lava does not flow very fast or far. The eruptions of Mt Ngauruhoe that caused

lava flows ~~para~~ released lava that flowed down the sides of the ~~the~~ volcano. This lava then cooled and hardened and became part of the mountain, causing the shape of the stratovolcano.

QUESTION TWO: 2021 EAST CAPE EARTHQUAKE AND TSUNAMI

On 5 March 2021, a magnitude 7.2 earthquake at a depth of 33 km, struck 124 km east of Te Araroa, on the East Cape of the North Island.

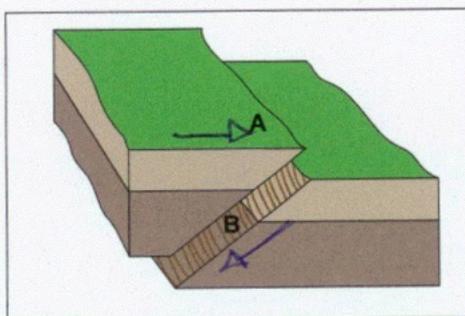
Large parts of the East Cape and Hawkes Bay were pushed 1 cm to the southwest.



- (a) An oblique reverse fault caused this earthquake.

Describe what a fault is AND add arrows to the diagram below to show the movement that occurred along the fault at positions A and B.

A fault is a crack in the earth's crust where two tectonic plates meet and shift.



- (b) The earthquake was reported as felt by over 52 000 people from across New Zealand, but no damage was reported.

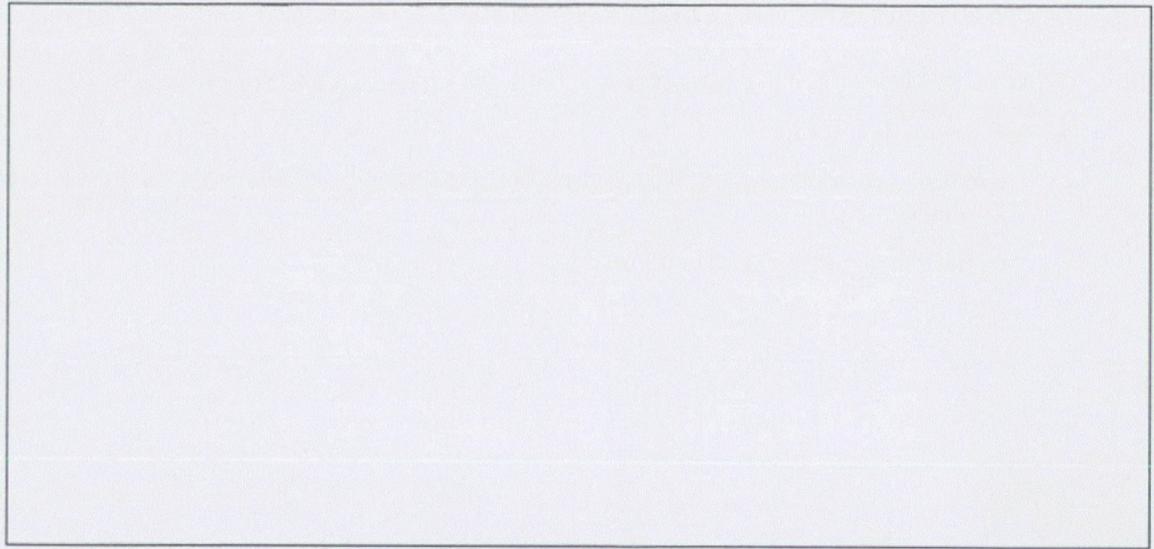
Explain, in detail, why this earthquake was felt by so many people across the whole country, yet no damage was reported.

In your answer you should:

- explain what is meant by the focus and epicentre of an earthquake
- describe seismic wave movement from the focus and epicentre
- explain the links between energy, seismic wave movement, and damage caused by an earthquake.

An annotated diagram may assist your answer.

The focus of an earthquake is where it starts deep in the earth's crust, whereas the epicentre is the point ~~above~~ ^{on} the crust right above the focus.



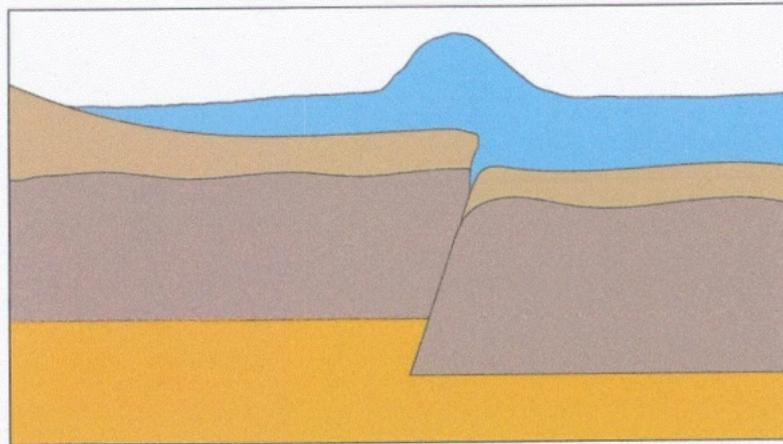
The extreme movement of the tectonic plates resulted in the formation of seismic waves. Seismic waves are sent away from the focus point of an earthquake like enlarging circles. These can travel very far and go through substances like the ground. Because this earthquake occurred in the Pacific ocean, the seismic waves ~~are~~ needed to travel through a lot of dense water. Most of this would have been absorbed by the water, creating a tsunami and therefore not ~~making it to the~~ allowing the strongest seismic waves to reach the shore, causing no damage to houses around the area.

(c) As a result of this earthquake, a tsunami was produced.

Explain, in detail, how this earthquake led to the formation of a tsunami.

In your answer you should:

- annotate and add arrows to the diagram below to show how the crustal movement caused a tsunami
- explain the energy transfers involved.



The shift of tectonic plates led a large amount of water to be moved under the surface. This resulted in the reaction of ~~to a large wave~~ a strong wave being created, increasing in height nearer to the shore.

QUESTION THREE: RAOUL ISLAND

On 5 March 2021, a few hours after the East Cape earthquake in New Zealand, two earthquakes occurred in the Raoul Island area, northeast of New Zealand; the first a magnitude 7.3, and the second a magnitude 8.1.

The magnitude 8.1 earthquake was the result of a megathrust earthquake along the subduction zone in the Kermadec trench.



- (a) Describe a tsunami wave.

In your answer you should consider the water column.

A tsunami wave is a strong and unstoppable wave caused by an earthquake, volcanic eruption, landslide, or displaced water column. It occurs when the body of water is disturbed by a large movement under the surface, including the addition of substances in the water (from eruption or landslide).

- (b) Both earthquakes led to tsunami warnings being issued throughout the Pacific.

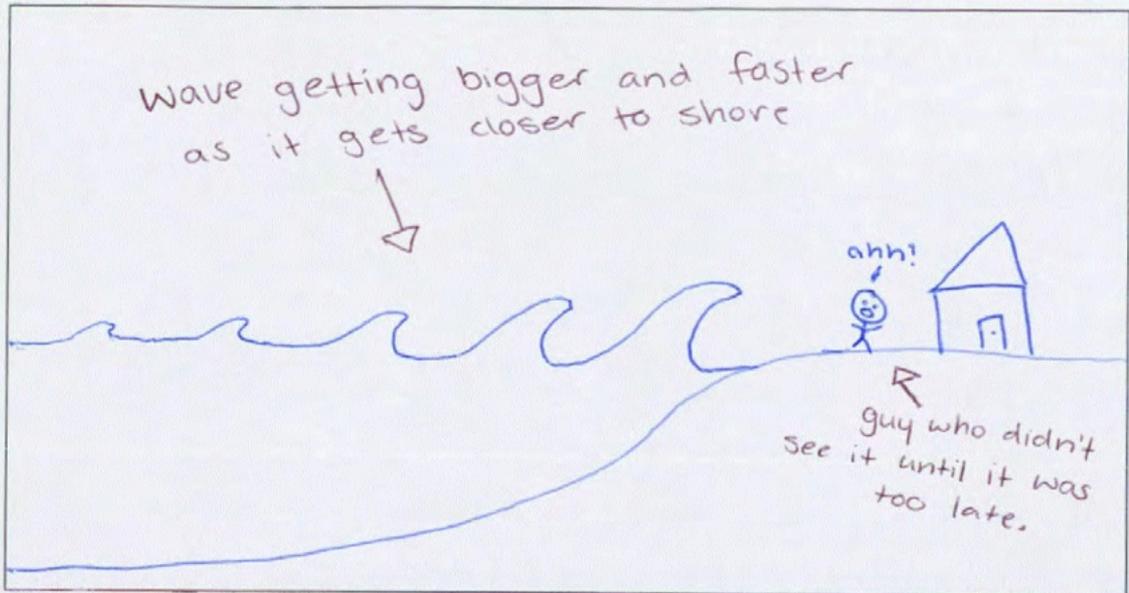
Explain, in detail, why this megathrust earthquake led to tsunami warnings being issued throughout the Pacific.

In your answer you should consider:

- how tsunami travel in open ocean
- changes to the height (amplitude), wavelength, and speed of the tsunami wave as it approached New Zealand's coastline, and the reasons for this.

An annotated diagram may assist your answer.

Tsunamis can be very unpredictable. What makes them so dangerous is that the true height and force of the wave is never visible until it reaches nearer to the shore, often when it is already too late to react. In the open ocean, there is plenty of space around on the surface and deep into the water for seismic waves to travel discreetly. However, once



the wave begins to get closer to the shore, the wave no longer has space and is forced to rise and speed up as there is less dense water to control and hold back the wave. Because tsunami waves are so difficult to predict, warnings are issued to all coastlines that may receive an unfortunately catastrophic wave.

Question Three continues
on the next page.

- (c) Raoul Island is the largest of the Kermadec Islands. The island is the summit of a mostly submerged volcano that has two caldera craters formed after previous eruptions.



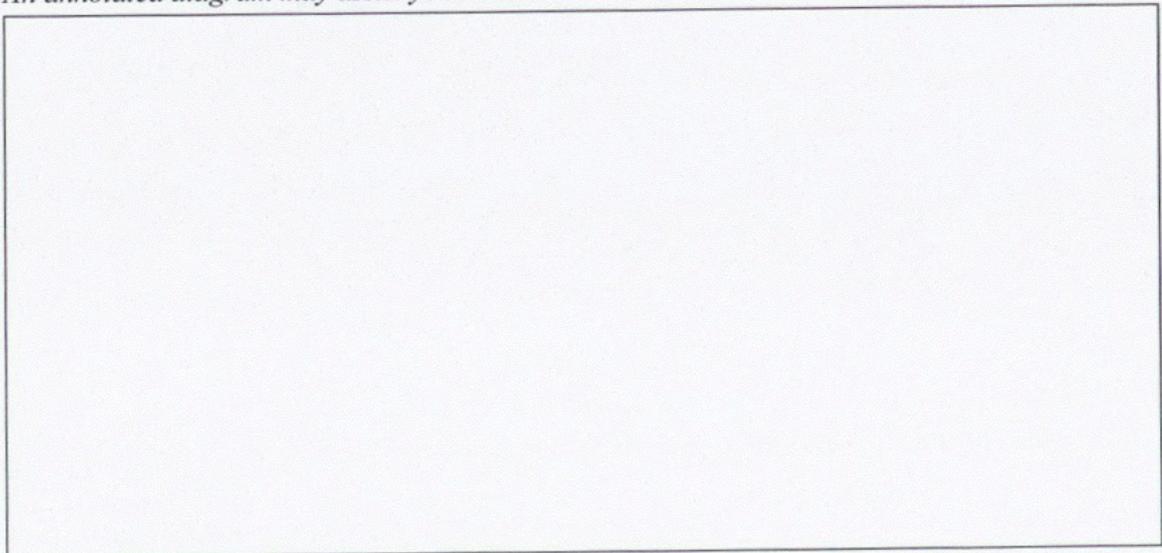
Adapted from: <https://www.geonet.org.nz/about/volcano/kermadecislands>

Explain, in detail, the tsunami risk associated with a caldera eruption from a volcano like Raoul Island in the Pacific Ocean.

In your answer you should consider:

- the stages of eruption for a typical submerged caldera volcano
- the different ways a caldera eruption can cause a tsunami.

An annotated diagram may assist your answer.



A caldera eruption from a volcano like Raoul Island could ~~be~~ have an extremely high tsunami risk as it is submerged underwater. Almost guaranteed to displace the water and cause a tsunami.

Calderas are formed as a result of a volcano with rhyolitic magma. These are the thickest magma type with high viscosity and the most possibility of trapped ~~ashes~~ gases. These volcanoes have the most potential of extremely violent eruptions. A caldera forms when a magma chamber is emptied and the volcano collapses, creating a crater.

Raoul Island is therefore likely to have a rather violent eruption which will often include large amounts of magma and rock to be thrown about in explosions.

This could create disturbances in the water by adding large masses of rock into it.

A tsunami could also be created if a caldera was created or worsened by an explosion leaving a deeper hole on the ocean bed to be flooded with water and resulting in a large wave on the surface.

Achievement

Subject: L2 Earth & Space Science

Standard: 91191

Total score: 10

Q	Grade score	Marker commentary
One	A4	The candidate was awarded an A4 as they labelled the crust type or named the plates. They stated that the Pacific plate was dense, therefore subducted, without giving what happened next, such as melting and less dense magma rising. In part (c), the candidate states that lava does not flow far, but does not link to magma characteristics, required for M5. They also stated layering, which formed the shape of the volcano.
Two	A3	The candidate was awarded an A3 as they could state that a fault line was a crack, seismic waves travelled far from the focus. The answer could have been enhanced by explaining where the focus was and the associated epicentre. The candidate also stated that energy was absorbed.
Three	A3	The candidate was awarded an A3 as they stated a tsunami was water displacement, and the wave amplitude increased approaching the shore, but incorrectly stated that the wave speed increases rather than slows down, and no reference to wavelength. The candidate also stated that a caldera is formed when the magma chamber empties and collapses.