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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.

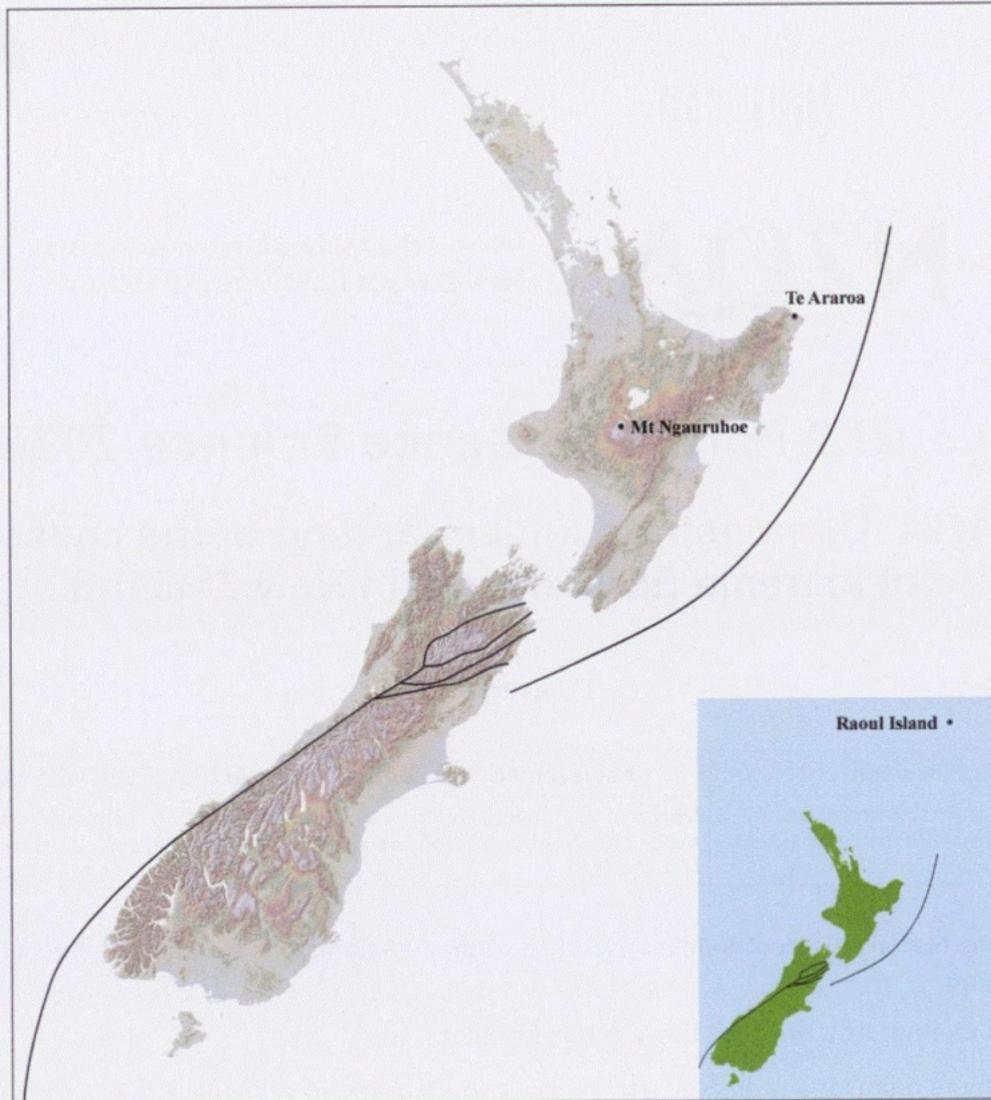
Do not write in any cross-hatched area (X/X). This area will be cut off when the booklet is marked.

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

Merit

TOTAL 15

Regional map showing locations referred to in this paper



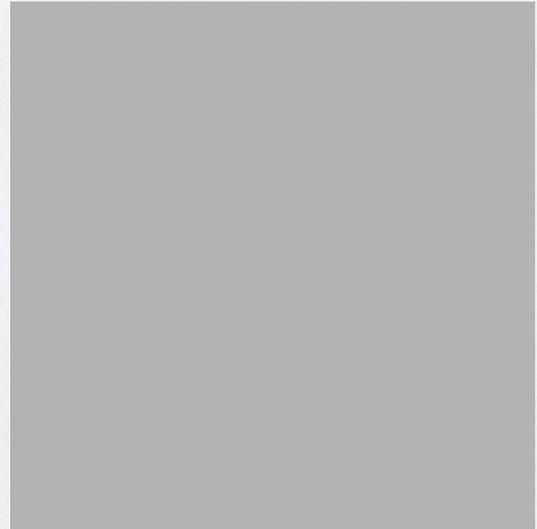
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The assessment begins on the following page.**

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.

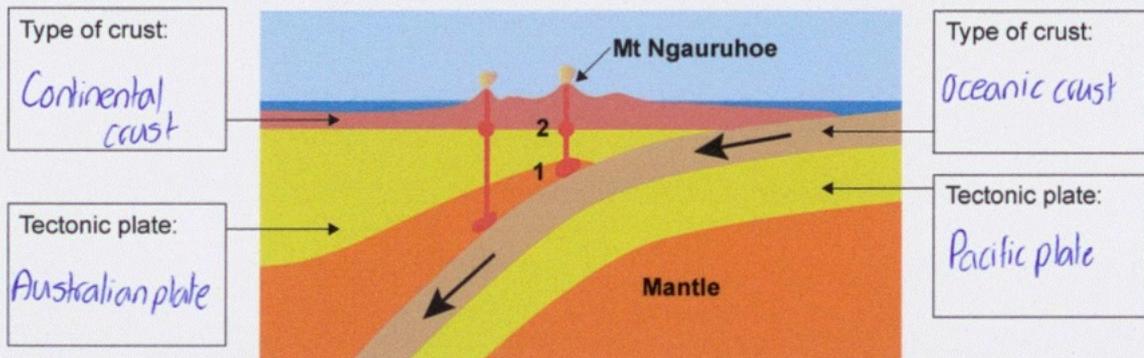
Mt Ngauruhoe formed approximately 7000 years ago, and is an andesitic stratovolcano.

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.



Source: www.gns.cri.nz/assets/Our-Science/Subfiles/Natural-Hazards-and-Risks/Subfiles/Volcanoes/Volcano-Fact-Sheet-Ngauruhoe.pdf

- (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 tectonic process that led to the formation of andesitic magma is by the movement of tectonic plates. In this case by looking at the map on page 2 it was at the Ngauruhoe volcano. The movement of tectonic plates was driven by convection currents caused by heat from the mantle. As the New Zealand sits on the boundary of Pacific plate and Australian plate seen in the diagram above.

As these tectonic plates move the ^{oceanic} Pacific plate subducts under the continental Australian plate because it is more denser. This is because it is at a convergent boundary and the plates are colliding with each other causing it to dive under each other in the Earth's mantle. This is all seen in the labeled diagram in part a. As the Pacific plate continues to subduct under the Australian plate it causes a lot of heat since it is under pressure. Pacific plate continues to subduct further ~~until~~ superheating until the rock with the mix of water starts to melt forming molten rock (magma.) This molten rock is the formation of ~~an~~ andesitic magma in the stratovolcano Mt Ngauruhoe. The andesitic magma has dissolved gases in it that bubbles and has the magma rises through the crust ~~the~~ breaks through small gaps in the Earth's crust like it seen in 1 in the diagram above. This magma continues to rise through the magma chamber like at 2 until the trapped gases inside the magma are able to expand out because the pressure has decreased as it rises up until it has reached the earth's surface and erupts out. This is a volcanic explosion and is a andesitic magma in the Mt Ngauruhoe stratovolcano is formed.

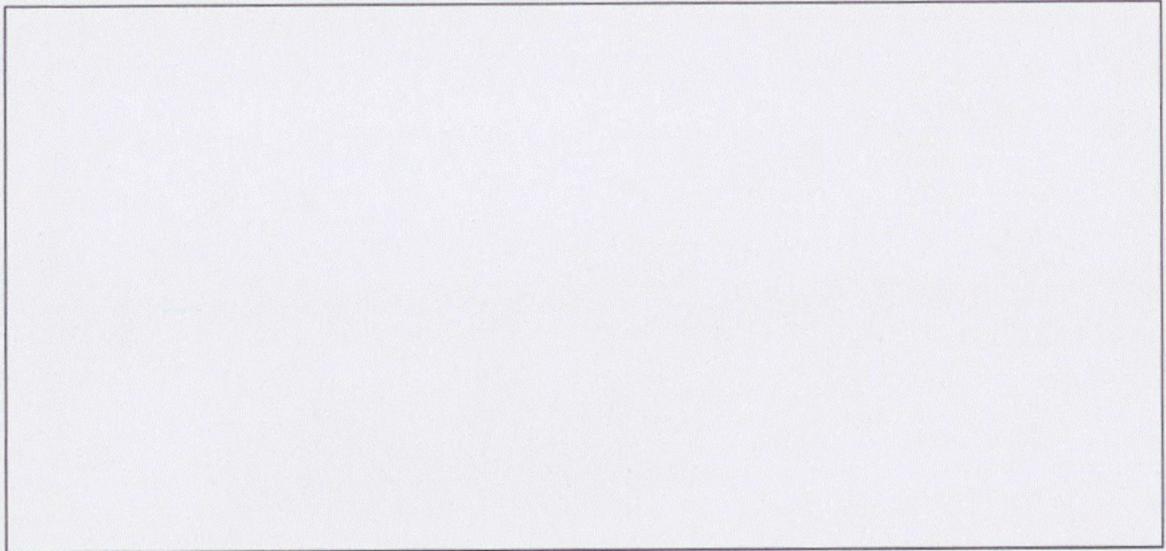
(c) Mt Ngauruhoe is an andesitic stratovolcano.

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.



Andesitic magma led to the formation of a stratovolcano by the characteristics of andesitic magma. Andesitic magma has an intermediate level of silica, viscosity, temperature and gas content. Because it has an intermediate level of silica it makes it have an intermediate ^{level} of viscosity causing it to become sticky. This means that the trapped gases inside the magma were under a lot of pressure causing them to be trapped. As the trapped gases rise up and the pressure decreases it's harder for the dissolved trapped gases to expand out because the andesitic magma has intermediate silica and viscosity causing it to be sticky. The stickiness of the magma makes it harder for the trapped gases to expand out. As the trapped gases finally expand out it causes a violent, explosive eruption. This is because of the characteristics of the magma being intermediate causes it

to be sticky and causing a bigger more violent eruption. This eruptive process produced were ash eruption and producing out andesitic lava, pyroclastic flow, lahars and ash clouds.

These eruptive products and magma composition helped link to the shape of Mt Ngauruhoe. This is because the layering was formed from the eruptive products like lava, pyroclastic flow, lahar and ash clouds. Each different product that was produced helped form the layering of Mt Ngauruhoe and plays a part in the way it was shaped. The magma composition helped form the shape of Mt Ngauruhoe. This is because of the amount of silica content causing it to have intermediate viscosity, made it sticky. This sticky magma caused the bigger eruption which caused the mountain to be bigger. The shape is formed because the magma that was turned into lava was also sticky meaning it didn't run very far and caused the cone shape. Compared to if it was more runny lava like basaltic which would run further forming a more gentle slope like a shield volcano. Therefore the layering and magma composition links to the shape of Mt Ngauruhoe.

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.

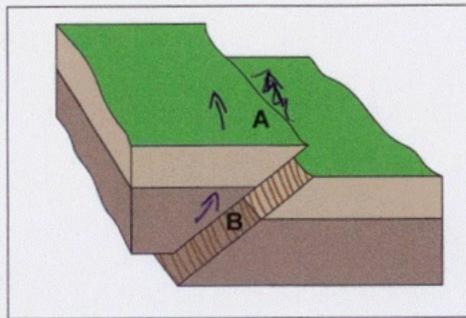
Large parts of the East Cape and Hawkes Bay were pushed 1 cm to the southwest.



- (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 fracture or zone on a faultline where the movement of tectonic plates is and how it moved.



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

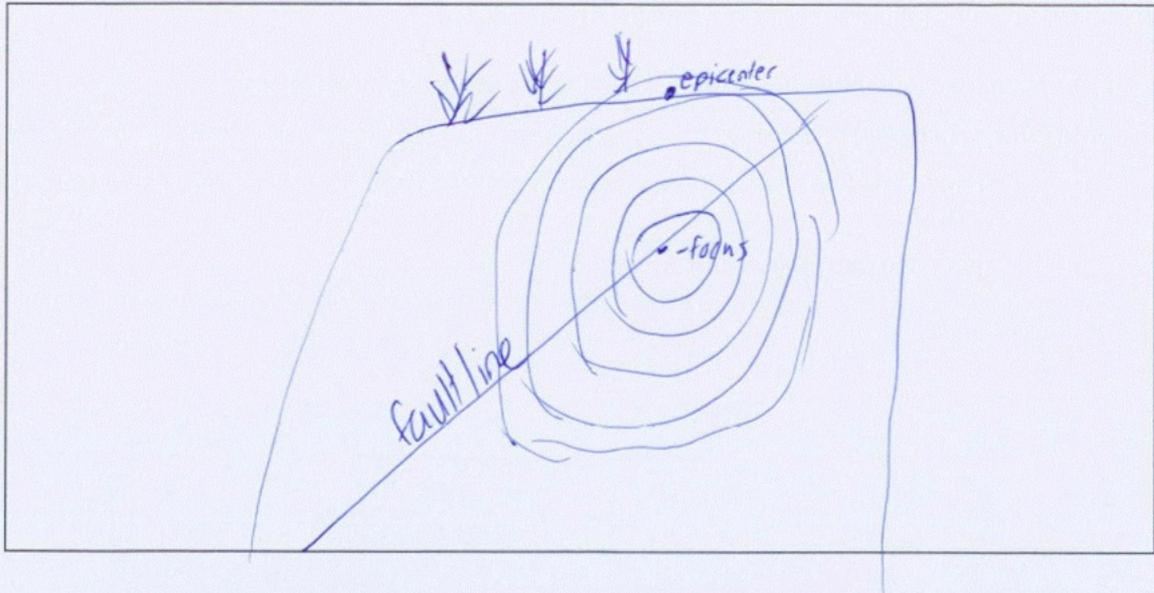
Explain, in detail, why this earthquake was felt by so many people across the whole country, yet no damage was reported.

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 earthquake was formed by the movement of tectonic plates driven by heat in the mantle. The movement of tectonic plates caused the oceanic denser Pacific plate to collide with the continental



less denser ~~plate~~ Australian plate ~~caused~~ a tectonic plate boundary causing a reverse fault to happen and the land pushed 1cm to the southwest.

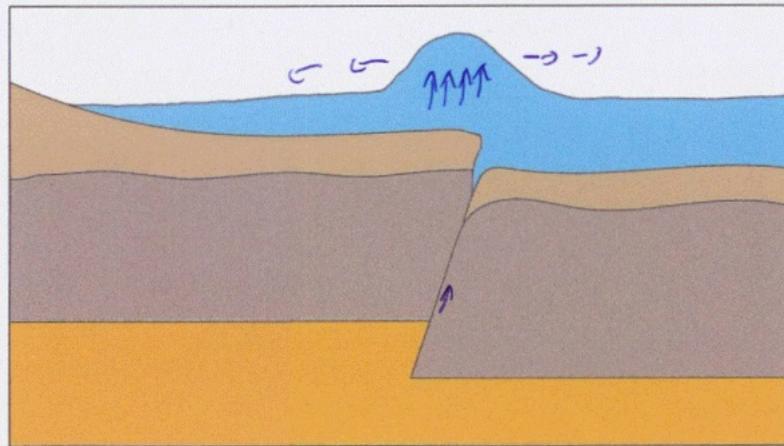
The focus of an earthquake is the ~~ground surface~~ point where the earthquake originated while the ~~epi~~epicentre is the point on the ground surface directly above the focus. As the earthquake happens energy is released in the form of seismic waves. These seismic waves travel up from the focus to the epicentre. The energy used in this was built up from rocks in the form of elastic potential energy as ~~a~~ stress build up along the faultline caused by the movement of tectonic plates. This caused the rock to get stuck due to friction and store the energy until the strength of the rock exceeds the friction cause it to rupture and that stored potential energy is transferred into kinetic energy in the form of seismic waves coming up from the focus to the epicentre. These seismic waves were realised in three ways. The first is P (primary) waves. They are the fastest and goes up and down. The second is the (s) waves which go side to side which is slower than P waves and go side-to-side. They cause more shear side damage. Lastly is the surface waves, these are the waves released at the surface and cause the most damage. The damage of

(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.



This earth A tsunami is a series of ocean waves caused by a vertical displacement of water. It is caused by this earthquake because of the movement of tectonic plates. ^{driven by convection currents caused by heat in the mantle} The Pacific plate and Australian plate collided ~~and causing them to be a strike slip reverse fault.~~ This movement and the Pacific plate to subduct under the Australian plate causing a reverse fault. This movement of tectonic plates caused stress to build up along the fault and the rock to get stuck due to friction storing potential energy. As the pressure continues to build the rock stays stuck until the strength of it exceeds the friction causing to be rupture. This is elastic rebound theory and all that elastic potential energy is released out. This sudden release of energy is then transferred into kinetic energy in the form of

Seismic waves. This causes the entire water column to be moved up or down being vertically displaced causing a tsunami. The tsunami then carries a lot of energy that is released out in the form of seismic kinetic energy moving the water column out in all directions with long wave lengths, small heights and fast moving. As the waves reach the shore the energy then changes and the waves slow down, the amplitude increases and the wave lengths decreased.

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 is a series of ocean waves caused by a vertical displacement of water. It is the movement of the water column having a sudden uplift or subsidence (down) of water and then spreading out in all directions.

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

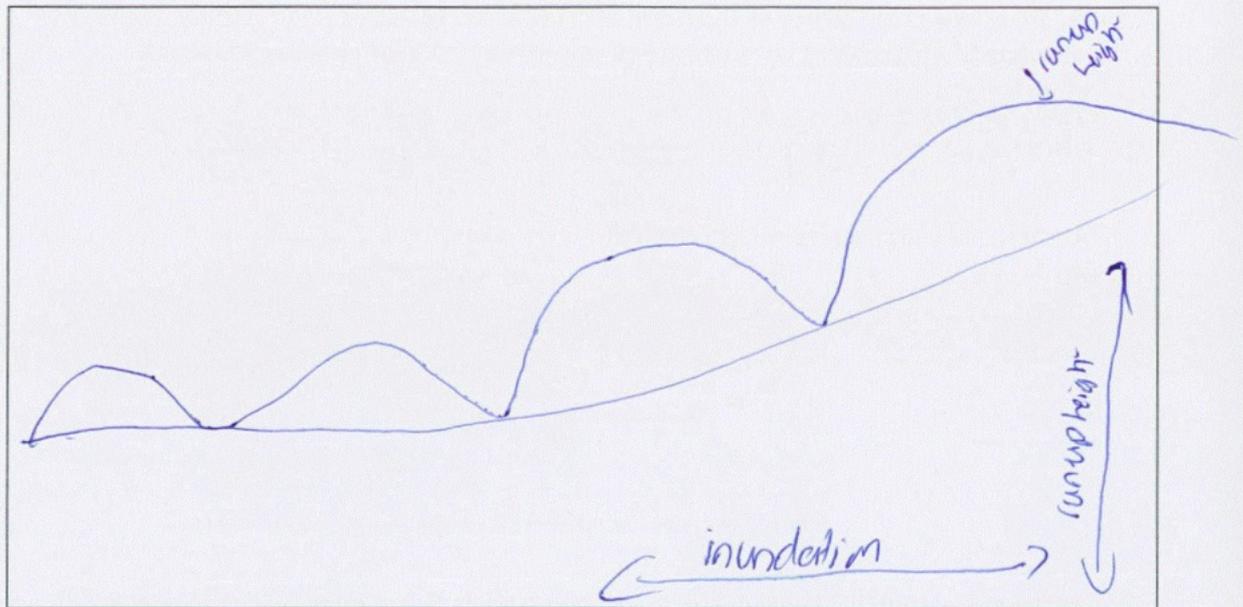
Explain, in detail, why this megathrust earthquake led to tsunami warnings being issued throughout the Pacific.

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.

Tsunami's travel in open ocean by the energy being released from the megathrust earthquake causing the water column to be moved up or down. This water gets vertically displaced and then gets spread out in all directions in the form of ocean waves. As the waves are fast moving & long wave lengths and short amplitudes. As the tsunami's waves approach New Zealand's coastlines the speed slow down. This is because of the land causing the seafloor



to slow down because of friction. This process is called shoaling. Since the waves have slowed down it causes the waves to bunch or pile up making the wave lengths longer. This means that all the energy in a tsunami is then transferred used in the amplitude of the waves since the wave lengths have decreased causing the amplitude to increase as it approaches the shore and New Zealand's coastline. This then makes the run-up height and inundation to increase. This is because the run-up height is the vertical height of the first wave that reaches the shore while the inundation is the horizontal height of the waves as it reaches the shore.

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.



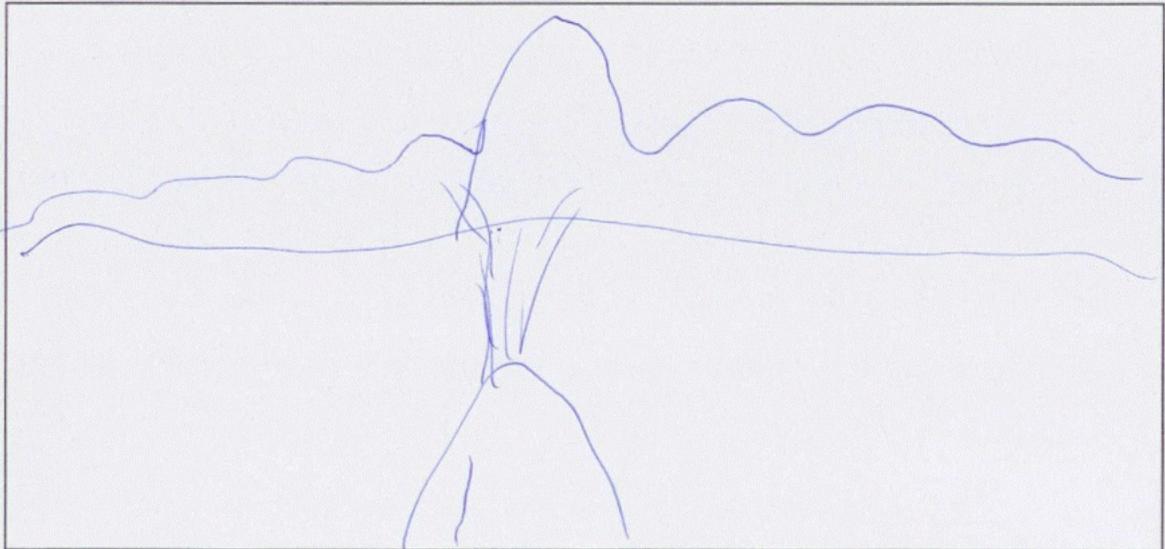
Adapted from: <https://www.geonet.org.nz/about/volcano/kermadecislands>

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.



The stages of eruption for a typical submerged Caldera volcano is by the movement of tectonic plates driven by convection currents caused by heat in the mantle. The Pacific, denser Pacific plate subducts under the Continental, less dense Australian plate at a convergent plate boundary. This causes heat to build up. As the Pacific

plate continues to subduct under, it starts to heat the further it goes. Sediment starts to build up and makes it subduct even more. The plates continue subducting until the Pacific plate starts overheating. This makes the rocks to start to melt. With the melted rock and water coming into it from the sea floor, the Rhyolitic magma is formed. This magma contains trapped gases that rise up through the magma chamber. As the pressure decreases the gases expand out causing a violent, explosive eruption. The magma chamber then gets drained causing the walls to fold in on themselves forming a caldera shape.

The caldera eruption can cause a tsunami by the eruption moving the water column up or down causing to be vertically displaced and therefore a tsunami. This water is then transferred out in all directions.

The volcano can also cause a landslide to happen which is a slope in the earth's landscape. By causing an uplift of water that is then spread out in all directions forming a tsunami.

The eruption can also lead to an avalanche or earthquake forming a tsunami by lifting up the water column up or down then released in all directions.

Extra space if required.

Write the question number(s) if applicable.

QUESTION
NUMBER

Question two b)

an earthquake doesn't just rely on the seismic waves. The magnitude of an earthquake can also affect this. This is because it measures how much energy is released. Since the earthquake had a magnitude of 7.2 more energy is released than compared to if it had a lower number on the richter scale. This will be why it was felt more but no damage. Since the earthquake had a deeper depth of 33km it meant that more energy was used to travel up from the focus to the epicenter. Meaning there was less energy released at the surface causing less damage. Compared to if there was a shallow depth where there was more energy released at the surface because less energy was used to travel up from the ~~epicent~~ focus to the epicenter causing more damage. The location of the focus/epicenter can also be the reason why there was no damage. This is because the location could have been further than the main city. Meaning that there isn't as much buildings to cause damage to. While if the location of the focus/epicenter was in the main city it could cause more damage because there would be more buildings and infrastructure around.

91191

Merit

Subject: L2 Earth & Space Science

Standard: 91191

Total score: 15

Q	Grade score	Marker commentary
One	M5	The candidate was awarded an M5 as they linked the characteristics of Andesitic magma to the formation of a steep side cone, such as intermediate silica formed magma that flowed far and the layering of lava and ash. In part (a) the plate and crust were correctly labelled, and in part (b), the density of the plate was linked to why it subducted and the subsequent melting. Even though the candidate had explained that water was present, it was not linked to the lowering of the melting point of the subducting rock.
Two	M5	The candidate was awarded an M5 as they linked the focus and epicentre to the release of energy and how energy decreases further away from the focus. In part (c), the displacement of water and moving in all directions, but it is not linked to the uplift of the plate, causing the gravitational potential energy of the water to be converted to kinetic energy.
Three	M5	The candidate was awarded an M5 as they were able to describe that tsunami waves slowed down approaching the shore due to friction, causing smaller wave lengths and increased amplitude. They recognised that in the deep ocean, wave lengths increase, low amplitude and extremely fast, but did not indicate that very little energy is lost. In part (c), the candidate had discrete points such as the magma chamber collapsing and the water column moving down, but no link to how the chamber collapsed or by explaining a phreatomagmatic eruption.