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Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Level 2 Earth & Space Science 2023

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 2–20 in the correct order and that none of these pages is blank.

Do not write in any cross-hatched area. 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.

Excellence

TOTAL 21

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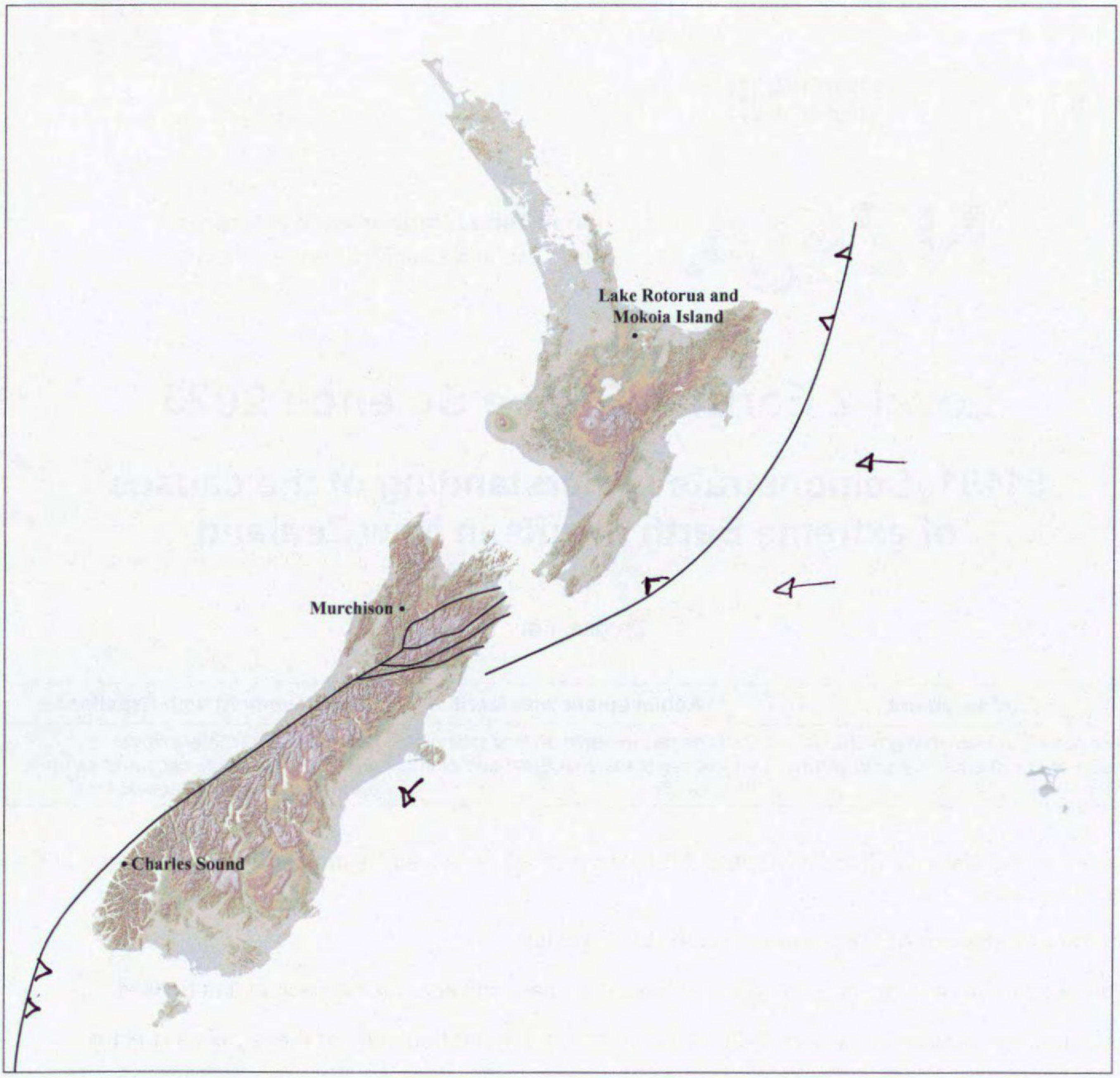
Regional map showing locations referred to in this paper



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The assessment begins on the following page.

QUESTION ONE: LAKE ROTORUA AND MOKOIA ISLAND

Adapted from www.mokoiaisland.co.nz

Lake Rotorua is a large rhyolitic caldera found in the Taupo Volcanic Zone (TVZ) in the North Island of New Zealand.

It was formed in a single eruption about 240 000 years ago.

Mokoia Island, found roughly in the centre of Lake Rotorua, is a rhyolitic lava dome that erupted sometime after the Rotorua caldera collapsed.

(a) Complete the table below to describe the characteristics of rhyolitic magma as either HIGH, LOW, or INTERMEDIATE.

	Temperature	Silica Content	Viscosity	Gas Content
Rhyolitic magma	800°C – 650°	65 – 75%.	Very Sticky	- water - Carbondioxide ~~relatively high~~

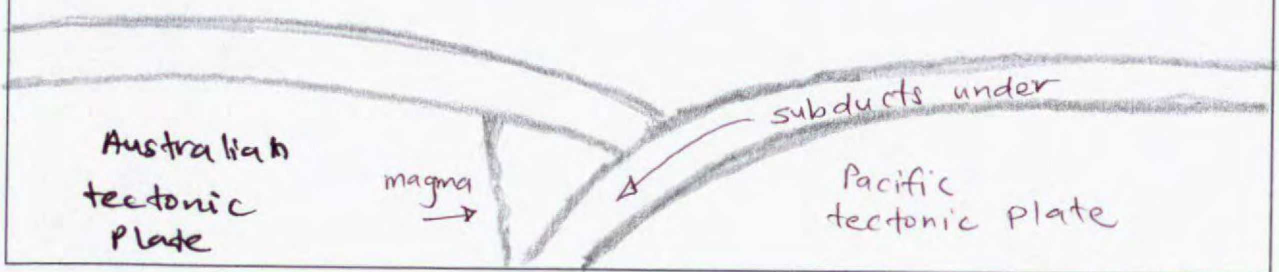
(b) Explain, in detail, how tectonic processes led to the formation of rhyolitic magma in the TVZ.

subduction zone

In your answer you should consider:

- the map on page 2
- the tectonic plates involved and their movement relative to each other
- the type of crust involved at the plate boundary. Au. & PP.
- the key tectonic processes that led to the formation of rhyolitic magma at this boundary.

An annotated diagram may assist your answer.



The Pacific Plate subducts under Australian Plate (continental crust) as the Pacific Plate is oceanic crust meaning that it is denser. Due to this, subduction zone is formed.

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This is the Taupo Volcanic Zone. This zone has either andesitic or rhyolitic magma which in this case is rhyolitic magma. Rhyolitic magma is formed due to the subduction of the Pacific Plate under the less dense Australian Plate. As the Pacific plate subducts under the Australian Plate, wet sediments of the oceanic crust also subducts. The subduction of Pacific Plate due to gravity, it moves closer to heat source causing rocks and sediments to melt. Since wet sediments contain water, it further lowers the temperature of the materials forming rhyolitic magma. The Pacific plate with basaltic crust has magma that escapes through cracks from Australian Plate (this is because the overlapping plate is stretched creating cracks). The hot magma melts sediments from the Australian Plate which is rich in silica. Due to the amount of silica content, it is highly viscosious allowing it to trap many gases leading to a violent eruption.

According to the map, Lake Rotorua is located in the North Island where the (oceanic crust) Pacific Plate is subducting under the (continental crust) Australian Plate.

(c) Explain, in detail, with reference to Lake Rotorua and Mokoia Island, how rhyolitic magma could produce both a caldera and a dome in the same location.

In your answer you should consider:

- any differences in the characteristics of rhyolitic magma in a caldera and dome volcano
- how a caldera is formed
- how a dome volcano is formed.

An annotated diagram may assist your answer.

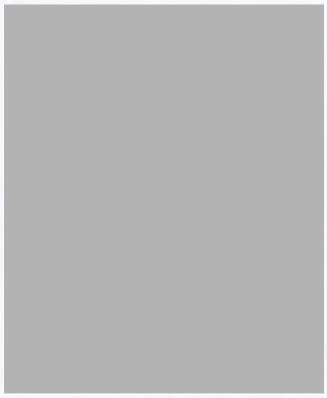
Caldera volcanoes are formed when the vent / crater of the volcano cracks / collapses whereas dome volcanoes form from rhyolitic lava flow

~~Caldera~~ ~~After the forma~~ Due to the formation of rhyolitic magma, there are two possible formation of volcanoes; caldera & dome. When rhyolitic magma reaches the surface, it causes an explosive eruption due to the pressure build up in gas bubbles trapped in the very sticky magma. This explosive eruption produces ash, pumice and phyroclastic flow. ~~The~~ Due to the violent ~~flow of~~ eruption, and pressure from ~~wate~~ heavy rain from the after effect of the eruption, the ~~crater~~ vent

collapses forming large crater. Overtime, the large crater (maar) is filled with water forming a caldera volcano:
Dome volcanoes are formed when the gases escape through cracks or an initial eruption. Once gases successfully escapes, leaving only magma, magma flow out smoothly oozing like toothpaste. Due to the very sticky property of rhyolitic magma, the lava does not travel far from the vent forming steep sides once it solidifies.

The difference in the characteristics of rhyolitic magma in a caldera & dome volcano is that in caldera volcano, gas ~~escape~~ ~~violently~~ bubbles are traped causing an explosive eruption whereas dome ~~ca~~ volcanoes occur ~~of~~ when gas has already escaped and lava can easily flow out.

QUESTION TWO: 1929 MURCHISON EARTHQUAKE

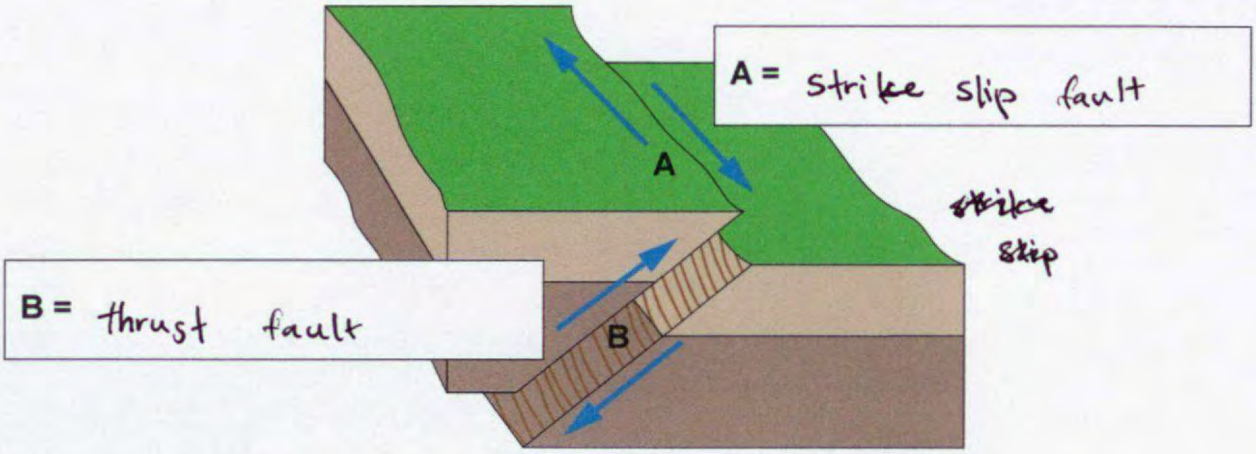


Source: https://en.wikipedia.org/wiki/1929_Murchison_earthquake

On 17 June 1929, a magnitude 7.3 earthquake at a depth of 20 km struck on the White Creek fault, 15 km northwest of Murchison.

The earthquake resulted in approximately 4.5 m of vertical uplift, and 2.5 m of sideways movement, along the White Creek fault. gravitational potential energy.

(a) On the diagram below, name the fault type represented by the movement at **A**, and the fault type represented by the movement at **B**.



(b) Explain, in detail, how a rupture along the White Creek fault line could lead to a magnitude 7.3 earthquake.

In your answer you should consider:

- the map on page 2
- the tectonic plate movements associated with this earthquake
- what a fault is
- the likely cause of this large-magnitude earthquake.

An annotated diagram may assist your answer.

When the pacific plate abruptly shoves itself benethe the Australian plate, it causes a powerful thrust earthquake

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~~Earthquake maren caused by eig... subduction of~~ The ~~the~~ Earth's crust is in constant movement giving it land features. The tectonic plates move very slowly, however, friction prevents the smooth flow which builds up pressure over time. The sudden release of this pressure (elastic potential energy) causes the earthquake to shake as the build up energy transfers its energy sending seismic waves. The release of the build up energy over time causes breaks in the fault. A fault is a crack or fracture caused by the movement of the crust. White Creek fault is located on the North west of Murchison where there is no subduction but there is collision. Due to the collision of the Australian Plate and Pacific Plate, there is fault movement. This movement is reduced which builds up pressure over a period of time. In between events, there is build up of energy over time. When the pressure is suddenly released, the energy causes the vertical uplift of 4.5m (gravitational potential energy) and a side way movement that causes a large maginitude of 7.3 earthquate. A greater magnitude causes more shaking. The disturbance along the White Creek fault line, the elastic potential energy was suddenly released and the pressure release was so stronge that it caused the ground to shake with a magnitude as high as 7.3. And due to the location of White Creek fault, where shallow earthquakes occur, the verticle uplift of 4.5m had a great impact (stronger seismic waves).

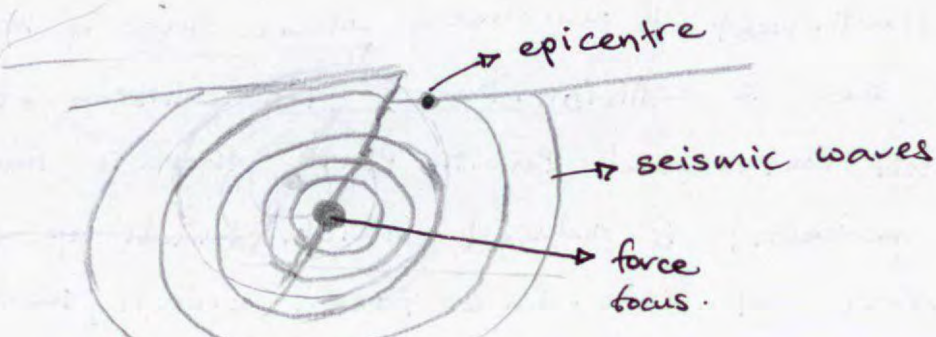
(c) The earthquake was felt throughout New Zealand, with the most intense shaking occurring within approximately 65 km of Murchison.

Explain, in detail, why damage and shaking was greatest close to Murchison, but the earthquake was felt throughout New Zealand.

In your answer you should consider:

- energy
- seismic waves
- the focus and epicentre of an earthquake.

An annotated diagram may assist your answer.



The energy released ~~suddenly~~ suddenly caused the shaking of the ground where the energy ~~transforated~~ transferred to seismic waves that is felt as earthquake. The epicentre is where the seismic wave first reaches the surface. Due to the sudden~~ly~~ release of build up energy, the seismic waves ~~trans~~ travel through rocks travelling far, however greater shaking was felt near Murchison as seismic waves lose energy in form of heat as they travel. so the closer ~~the~~ surface, the greater the shaking felt. ~~Magnitude determines the~~ The depth affects the amount of shaking occuring, as ~~the~~ ~~sl~~ shallow earthquakes (less than 40 m) ~~be~~ enable seismic waves to reach the surface easily without loosing much energy.

~~the shaking of the ground~~ Since strong shaking is felt closer to the epicentre, & this can lead to liquefaction. This happens due to strong strong shaking that ~~separates~~ ~~brings the water tog higher~~ separates water from silty, sandy and saturated soil. Liquefication reduces the strength ~~of~~ and stiffness of soil making buildings tilt or partially sumerged in soil. After the shaking stops, the soil settles down pushing up the water which causes flood. Even just shaking of the crust brings devistating events such as building collapse, road cracks, bridge collapse. Also, this earthquake could also cause landslide ~~which~~ (submarine avalaunche) which could cause a local tsunami.

QUESTION THREE: 2003 FIORDLAND TSUNAMI

On 22 August 2003, a magnitude 7.2 earthquake struck off the coast of Fiordland, triggering many landslides in the remote area.

One of these landslides fell into Charles Sound causing a small local tsunami with a 4 to 5-metre high run-up.

The earthquake also generated a small tsunami in the Tasman Sea, recording a 300 mm high run-up in Jacksons Bay, and a 170 mm run-up at Port Kembla, Australia.

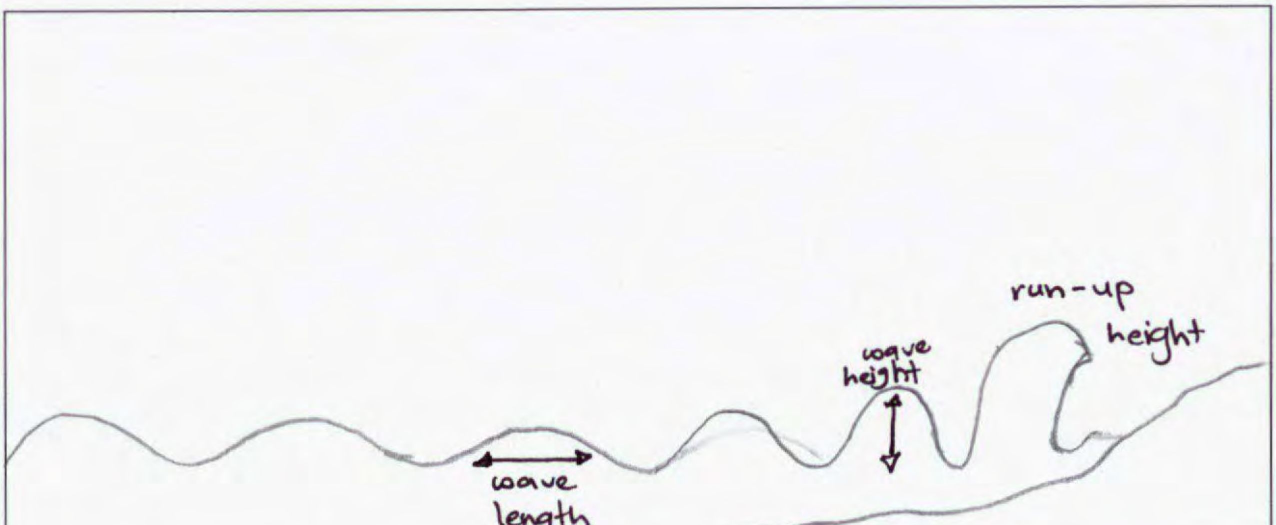
Adapted from https://static.geonet.org.nz/info/images/tsunami/historic/Fiordland-earthquake-tsunami-August-22-2003.png

Charles Sound

Source: https://teara.govt.nz/en/photograph/6209/landslide-fiordland

(a) Describe what is meant by the run-up height of a tsunami.

An annotated diagram may assist your answer.



Run-up height is when the waves of tsunami reaches the shore therefore ~~bui~~ it increases (amplitude) height and decreaves wave length to go ~~further~~ further inland. (The height of the first tsunami wave is run-up height)

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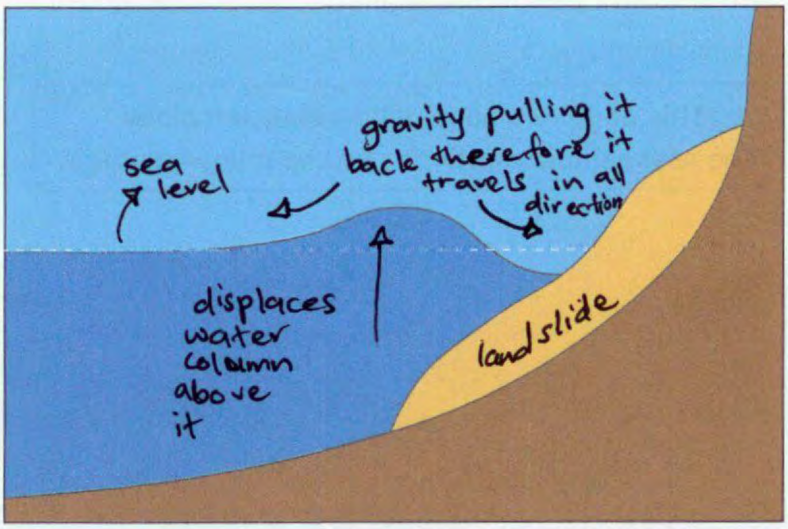
The assessment continues on the following page.

(b) Explain, in detail, how the landslide in Charles Sound generated a tsunami, and why it produced a large run-up height.

In your answer you should:

- consider what a tsunami is
- use arrows and annotations on the diagram below to show how a landslide can produce a tsunami
- consider how the height and width of Charles Sound affected the tsunami produced.



Tsunami are large waves caused by the displacement of large volumes of water. A land slide in to ~~the~~ water (submarine avalaunche) causes displacement as displacement of the sediments is directly ~~real~~ related to the displacement of the water column above it. When the sediments fall into the water, it causes displacement, ~~however the~~ transfering ~~(kinetic)~~ potential energy to the water (kinetic energy) allowing it to travel long distance without loosing its energy due to its waive length. When ~~the~~ ~~wat~~ tsunami reaches shallow water, it increases height and decreases wave lenght as there is still so much energy left in the water. The sea bed slows the speed of the tsunami due to friction. The waves height increases so much and travels inland causing devistating damages.

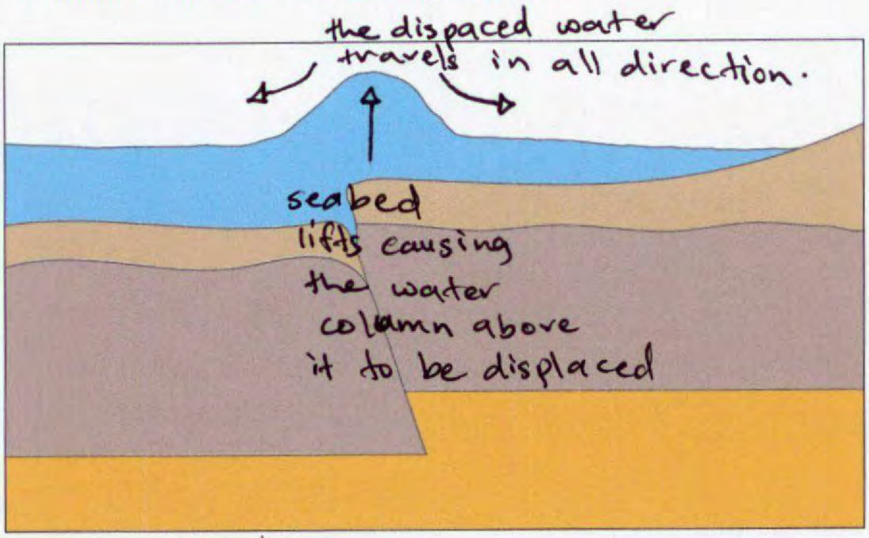
The height of Charles Sound is steep and width is narrow reducing the travel ~~time~~ distance of the ~~st~~ tsunami causing a greater amplitude. Since tsunamis can travel up to ~~1000km~~ 100 km/hr, without losing ~~to~~ much energy, in this case, the traveling distance is very short enabling a faster wave run-up with more energy. Since the land slide came down from a slope, ~~there is~~ ~~a~~ ~~po~~ the sediments could have spread out rather than just dropping causing a bigger displacement of water.

Question Three continues on the next page.

(c) Explain, in detail, how the earthquake generated a tsunami in the Tasman Sea, and how this tsunami could produce a tsunami wave in Australia.

In your answer you should:

- annotate and add arrows to the diagram below to show how a tsunami can be produced by an earthquake in the Tasman Sea
- explain the energy transfers that occur
- explain how tsunami waves can travel long distances.



A magnitude of atleast 7.5 is need for a tsunami to occur. Due to the ~~sa~~ uplift of the seabed, the water column above ~~it~~ ~~also~~ was displaced. The energy from the ~~seismic wave~~ transfers to the water creating convection ~~cat~~ current. ~~That~~ Due to gravity, the water falls back enabling tsunami to travel in all direction. Due to the energy transfered to the water from the earthquake, the tsunami can travel far. Tsunami's do not lose much energy due to it wave length. ~~The displacement of water due to an earthquake~~ displacement (uplift of the seafloor) also displaced as the same amount of water above it. The sudden release of build up pressure that lead to an earthquake, displaced the water column above it. Due to gravity, the water falls back but there is still so much energy in the water that does not die out, therefore, it starts to ~~tract~~ travel in all direction. This energy is ~~transferred to~~ convectional current. The tsunami is able to travel far without losing ~~its energy is a~~ much energy ~~is~~ due to its wave length. The long wave length preserves the energy while travelling far distance, however, once the tsunami reaches shallow waters, it reduces it's ~~to~~ wave length and increases its height due to the energy. Tsunamis are relatively fast however, when ~~the~~ reaches shallow waters, ~~the~~ it slows down due to frictional force from the seabed. Since the magnitude was less than 7.5, the wave height was rather small (300mm) & (170mm). In order, to go further in land, run-ups have shorter ~~wat~~ wave lengths and longer amplitude (~~wat~~ wave height). The ~~ear~~ earthquake also caused a tsunami ~~in~~ at Port-Kembla due to its "all directional movement". However, the tsunami at Port-Kembla was ~~mo~~ smaller than ~~Tasman Sea~~ Jackson Bay was because of the longer distance it covered compared ~~to~~ ~~to~~ which made it lose some energy.

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

Extra space if required.
Write the question number(s) if applicable.

QUESTION NUMBER

91191

Excellence

Subject: Earth & Space Science

Standard: 91191

Total score: 21

Q	Grade score	Marker commentary
One	E7	The candidate has a clear understanding of how Rhyolitic magma is formed. For an E8, the candidate could have mentioned magma pooling under the Australian plate or less dense magma rising.
Two	E7	The candidate has a clear understanding of how earthquakes are generated in this area. However, how the plates caused friction, for example as the plate edges are not smooth could have enhanced the answer.
Three	E7	The candidate has a clear understanding of how tsunamis are generated. However, clarity was needed about the wave height in the ocean.