SUPERVISOR'S USE ONLY

S

93104

931040

Draw a cross through the box (☒) if you have NOT written in this booklet

TOP SCHOLAR

Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Scholarship 2025
Earth and Space Science

Time allowed: Three hours
Total score: 24

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 answer ALL the questions in this booklet.

Pull out Resource Booklet 93104R from the centre of 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 ( ). This area may be cut off when the booklet is marked.

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

QUESTION ONE: VOLCANOES UNDER THE ICE

Explore the stages and features of a glaciovolcanic eruption. As there is considerable ongoing ice loss in the region, consider the long- and short-term implications for volcanism in Antarctica.

The glaciovolcanos are mostly formed at divergent plate boundaries where the plates are moving apart at a 'rift zone'. This causes there to be a space between the plates where magma / molten rock from the mantle can quickly rise up through. The magma is usually basaltic as it will not pool in a chamber, giving no opportunity for silica to increase the viscosity of the magma. In the Pine Island Glacier area the East and West Antartic plates are moving apart forming the rift system which can be seen in Figure 1 as having many volcanos with a few active volcanos closer to the rift, likely from magma that has come up more recently. The magma could potentially form other types such as andsetic or rhyolitic ~~if~~ if it was unable to immediate penetrate through the crust it may pool in a magma chamber bellow the crust and ice untill the ice melts and there is less force down or untill the pressure builds up enough for the magma to break through the surface. However the most common magma type would be basaltic, similarly to a Hot spot volcano. The stages / how the eruption occurs will varry based on the thickness of the ice above the magma. This is demostrated in Figure 2. Thicker ice of 0.5-1 km has a much different compared to thinner ice of 200-500m. This is because with the thicker ice, not all of the ice will immediatly melt and therefore the gas such as CO_2 and ash cannot penetrate through to above the ice surface, rather the ice more near the volcano cone and where the magma (basaltic) is will melt when it comes in contact with the magma. The high tempreture magma will contact the ice which melts the ice to a certain thickness, but not enough when the ice is 0.5-1km thick to break the surface. As ice melts the fresh water will flow down the side of the volcano and drain. Any gases that form from the eruption will either condense when tempretures are low enough due to the thick ice or be trapped under the ice. Since the ice is so thick they will not be released through the surface. The melting ice near the volcano will continue untill the magma flow stops, creating an ice flow seen in Figure 2, as when the water forms and drains, new ice flows down to replace it, which ~~allows~~ also melts creating the slow. This will thin out the ice and creates a bowl shaped depression on the ice surface. The volcano quickly becomes more cone shaped as the basaltic magma which reaches the ice solidifies to igneous rock on the sides of the volcano, this is different from a typical *.

In comparison, when there is thin ice of 200-500m above the volcano when the magma rises it ~~instantly~~ quickly melts the ice, ~~and~~ which forms a pool of water, ~~when~~ then as more magma (basaltic) rises, a pherromagmatic eruption occurs. As the magma hits the water the eruption is violent and produces large amounts of gas which can be seen in Figure 2, as the magma evaporates the water (which formed from the melting ice — as ice was thin so quickly melts away) producing a violent steamy eruption. As there is no longer ice above the eruption site, as it quick melts, ash and tephra are formed and rises up along with the steam produced. In comparison, to the eruption with thick ice, the volcano shape formed with the thin ice is, more similar to a shield volcano and it has a larger crater/opening at the entrance. This is because the basaltic magma will not immediatly contact the ice - as there is less ice above, therefore the tempretures are less dramatic and less cold (as the water has higher tempreature than the ice). This means the basaltic magma can flow for longer before solidifing to igneous rock in comparison to the eruption when the ice is thicker. The volcanos therefore resembles a shield volcano, while the thick ice volcano resembles a cone. The larger entrance/opening of the thin ice volcano seen in Figure 2 is likely due to the ~~explosive~~ violent production of gas / steam that occurs when the magma contacts the water (phreromagmatic eruption). The eruption with thinner ice is more explosive as the water evaporates and the magma will not solidify as quickly, less water will drain as most of it will evaporate to form steam.

Due to climate change, the ice caps in Antartica are melting. This process is speed up by volcanic activity. The volcanic activity increases the melting of ice however, the primary cause is climate change causing areas such as Pine Island Glacier to reduce in thickness by 1 m per year. The activre volcanos erebus and deception are 25 times hotter then the dorment ones meaning the melting of ice caps in those areas must be extremely high, along with Amunden provice and Marine Byrd land wher there is many dolmant volcanos. The melting of ice caps ~~dot~~ reduces the weight of the ice - so there is less pressure on the crust (Figure 3). This means it is easier for the basaltic magma to break through the crust causing an increase in volcanic activity in the short term. There would be more pherromagmaic, violent eruptions in the short term as well as the ice is thinner all around the west of Antartica. In the long term, this increase in volcanic activiy would lead to further ice melting and more CO_2 in the atmosphere, which is a green house gas and traps heat in the atmosphere - contributing to the enhanced greenhous effect. Both of these are positive feedback loops which speed up the effects of climate change and global tempreature increase.

This would mean Antartic has less ice formation and more ice melting due to the short term increase in volcanic activity. Eventually there may be so little ice left that the volcanic activity is Anartic starts to expose crust / land. It will increase global warm in the long term which could result in more volcanic activity.

*.. basaltic eruption as the magma is thin and low viscosity (as low silica) and usualy forms a shield volcano as it takes longer to cool, however as it reaches the cold ice it soldifys quickly despite its warm tempreatures.

Intro
Ocean temp rise
Upwelling
Slowing THC – slow upwelling
Southern moving made

QUESTION TWO: WARMING OCEAN

Explore how shifts in the Subtropical Front have led to the warming of the ocean by the Chatham Rise. In your answer, consider oceanic and atmospheric processes. Furthermore, discuss what effects a continuation of the shift in the Subtropical Front would have on the marine biodiversity and fisheries on the Chatham Rise.

Measurements in the Subtropical Front by the Chatham Islands have found tempretures rising which is a cause for concern due to the importance of this area. The Subtropical front is where cold, dense nurtrants rich deep water from Antratic regions upwells and therefore mixes with the warm subtropic water. This is important for tempreture regulation and providing nutriments to the surface for phytoplankton such as diatoms and cocolithaphors to feed, which allows for a phytoplankton bloom, creating an area of high productivity for fisheries. However due to global climate change and atmospheric process the position of the upwelling - Subtropic Front is being moved South, ~~or~~ away from new Zealand. The upwelling is part of the thermohaline circulation. On a global level, this occurs because the average global tempreature is rising → leading to warmer oceans which makes it hard for CO_2 ~~to~~ to dissolve in the ocean and creates a positive feedback loop which further increases tempreture, meaning oceans contine to get warmer. At the poles this means that there is less density difference in the water and causes the downwelling at the poles to slow, which turn means the whole thermohalince circulation slows. Since upwelling is a part of the THC it means the upwelling at the subtropical front is reduced. This means less cold dense nuritent rich water upwells - so less phytoplankton blooms and less fish. This would have been dectected using the Argo float (figure 2) as it can flow with the currents. The slowing THC and lower density difference contributes to the movement south of the sub tropic zone, however it isn't the only factor to consider.

Atmospheric process are also contributing to the change. The Southern Anular Mode is the atmospheric process which involves the wind movement of the roaring fortres and furios fifltres, westerly winds. The westrile winds have strengthed and moved south toward high lattitudes, causing a negative period of the southern Anular Mode. - change to the southern anual mode. The south moment of these winds places when at higher lattitudes and reduces the westriles around NZ and the chatum rise and causes north eastly wind to increase. This would mean that the warm subtropical surface currents which bring warm water to new zealand from the South pacific Gyre (figure 4) would increase and ~~carry the water~~ bring more warm low density sub tropic water to NZ, which contributes to the movement of the Sub tropic Front. This is because the negative Southern anual mode (SAM) means the westirles move down and wind from the north east, from the South Pacific Gyre increases, which increases surface current bringing warm water. This would increase water tempreatures near the Chatum rise, meaning the upwelling occurs further south. Additionally, the Southern Anual Mode causing stronger westriles in south would increase the surface currents moving west to east of the ACC. This means more cold denser water is transportned away from the Chatum rise.

The stronger tempreture gradient in the Southern Ocean means upwelling is more likely to occur near there as there is a density differnce between the warm surface water and deep cold water. Whereas due to changes the Chatum Rise is primary warm, low density water.

This is also impacted by the El-Nino Southern Oscillation (ENSO). During the ~~El~~ La Nina periods the trade winds are "Stronger" so warmer waters from centeral and east Pacific shift closer to New Zealand and Austrialians and the north eastrile winds are prvailing compared to Westriles across New Zeland. This matchs with the SAM as the westirdes are shift southward and are stronger closer to Antartica then to NZ. The increase in north east wind increases surface currents and warm water which flows from subtropic regions - such as south pacific gyre. This along with the warmer waters due to La Nina, ~~w~~ means water tempreture increases. This can be seen in Figure 4 as areas near the Chatum rise are warmer than today and just off Tasmainia the most dramatic tenpreture rise of 1.5°C is seen. This is likely because of the warm waters of La Nina, and surface Currents from north eastriles inceasing (SAM and La Nina) and

* (~~retfer~~ refer to back for EL Nino comparison)

* Upwelling occurs more south as thats where there is now density difference.

there is no upwelling occuring near Tasmainia - so the warmer tempretures are less regulated compared to near the chatum rise - which is why it is warmer off Tasmainia.

The ~~west~~ north-west of NZ is cooler as there are less westriles and therfore less surface currents bringing warm water from the ~~West Aust~~ East Austrialia current, therefore lower water tempreatures.

As the Subtropic front has shifted due to the global tempreture change and atmospheric process, the oceans by the chatum ~~is~~ Rise is warmer. This is unfortunate as it means upwelling of cold nutrient dense water is no longer occuring near the Chatum rise.* This means less nutrients is being brought up to the surface for phytoplankton, therefore less of the phytoplanktons energy goes into reproduction ~~and more to~~ Therefore there will no longer be phytoplankton blooms which will impact the whole food web as there will be less small fish - as they have less food (as less zooplankton because of less phytoplankton). Therefore there will be less big fish and a lower productivity in the area. This means species will die off in the area as there is insufficant food source - so there will be less fish for fisherys and less marine diversity in the Chatum Rise as species will either die or have to migrate to find food source. Its important that this is studied so we can adapt with climate change and slow the effects.

* If the shift of the Subtropic front continues it will keep moving further from NZ which will impact NZ fisheries and marine diversity in the area.

Monitoring these changes allows us to see the rate of impact of climate change.

QUESTION THREE: SEASONS IN OUR SOLAR SYSTEM

Analyse how seasons on Mars, Uranus, and Neptune would be different to those on Earth by comparing eccentricity, length of orbit, distance from the Sun, and axial tilt. Additionally, evaluate the role that solar radiation plays in the planets' seasons.

Season are ~~charactired~~ by changes to tempreature, climate and weather over time, and are impacted by distance from planet from Sun, orbital length and eccentricity and the tilt. The season change based on the amount of direct solar radiation.
For Earth, the tilt is 23.4° and eccentrcity is 0.0167 this means, due to the tilt, when ~~they~~ Earth is closest to the sun (perihelion), the South is tilted more towards the ~~sume~~ sun therefore it is summer in the south as more direct radiation from the sun arrives at the south and winter in the north as it is tilted away from the sun. When the ~~Ea~~ Earth is furthest from the sun in its elptcal orbit (aphelion) more radiation is recieved by the ~~atmosphere~~ northern hemisphere and it is summer in the north - as it is titted slightly towards the sun (more direct radiation) and is winter is the South.
Inbetween these seasons is spring and autum. which occur at opposite times for the northern and Southern hemisphrer. Spring always occur after winter and Autum after summer.

Mars is the next furtest from the sun and has a longer orbit period, larger eccentricity, but a similar tilt angle to earth of 24.9°. This means its likely to experience opposite seasons in the northern and southern hemisphere at one time, as earth does as the ~~tilt~~ tilt angle is only slightly more

therefore the northern hemisphere would experience an (one specific hemisphere
equivilant to 'summer', but slightly more ~~extreme~~ direct to a hemisphere as the
tilt angle is slightly larger - so more direct radiation
to one hemisphere. And the southern hemisphere would
expience winter and vice versa. Mars recives
less solar radiation so the seasonal changes would
be less dramatic compared to Earth.
The eccentricity is higher so the furtherest point Mars is
from the Sun would be comparitivly greater, along
with the nearest to the sun. The length of orbit for
Mars is 1.88 years - so the seasonal changes would
occur slower compared to Earth, however out of the
planets the seasons of Mars would be most similar
to those of Earth.

Uranus is much further from the sun as it is a gas
giant (19.2 AU) and therefore has a much longer
orbital length of 84.1 years. It also has a ~~longer~~
~~er~~ higher eccentricity then Earth of 0.0459.
What makes the most difference compared to earth
is Uranus's axial tilt which is extreme at 97.8°.
This means that the seasons are different to Earth.
The seasons of summer and winter are very extreme
as the 97.8° tilt means that during the Southern
Summer solstice the ~~p~~ axis is almost align with the
sun, ~~e~~ meaning the South pole is always expericing
direct radiation from the sun in the same area - the
South Pole. This means the Northern ~~side~~ role ~~of the~~
Uranus will experience no direct radiation in this

time of the souther summer as it is blocked by the south side. This means during Sommer and winter in both the north and south, the 'winter side' will recive no direct radiation and the axis of rotation means the radiation is limited to only the area where it is 'summer' this means during sumer and winter there will be no day/night cycle for Uravs, making it very different from Earth and extreme temprature*
During the spring/autum periods there will, however be a day/night cycle as the sun radiation hits slightly to the north or south side of the equator. A northern spring, means a southern autum however the tempreture difference will not be that extreme. This can be confimed fron reaserch demostrated in figure 3, it shows the brightness of clouds in the northern hemisphere increasing this means it was coming out of a northern winter and heading into a northern spring. As the clouds are initally dark as they recive no radaiation from sun, however as it moves into spring the northern hemisphere is angled slightly toward the sun and we can see the amount of radiation the north recives to increase as the clouds are brighter, meaning they are reflecting income radation.

*(difference between season temp is extreme)

The temprature difference will be very minnor between the spring and autum periods for nepture as the radiation is direct very near the equatior, so less tempreature variation. It will also have a day/night cycle in spring and autum, but not in summer and winter due to the axial tilt.

In comparison to Earth Uranus has a more extreme difference in its summers and winters relative to the amount of solar radiation it recieves (which is much less then Earth). The difference between Uranus springs and autums will be very small, however they are the only times the day/night cycle will occur. The seasonal periods will take longer as it has a longer orbital period compared to Earth. Additionally, as it has a higher eccentricity the amount of radiation will change - as distance from sun changes so one summer may be ~~higher temp~~ more radiation than the other polar summer eg.

Neptune has a slightly larger tilt axis compared to Earth, similar to that of Mars. It has a lower eccentricity of 0.0097, meaning it stays a similar distance from the sun for all of its orbit. This means its seasons will take longer periods of time due to its larger orbital period. Due to the tilt it will experience seasons in a similar way to Earth and Mars, however as it recieves such a small amount of radiation from the ~~sea~~ sun the seasons will not be very dramatic, and very little to no change will occur - as low radiation and eccentricity.

The amount and directness of solar radiation is what determines seasons, compared to Earth the seasons of Neptune and Mars will be less dramatic and see less change between the seasons as they are further from the sun and recieve less radation. The seasons of Uranus are quite different to Earth as the summer/winter change is more dramatic relative to the amount of radiation

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

QUESTION NUMBER

3 Uraus recieves compared to Earth. Whereas Uranus's spring and autum seasons will have much less of a dramatic diffencece as the radiation hits so near to the equator - so Earth will have a larger spring / autum season change compared to Urans (realitive to the amount of radiation they recievere respectively).

Overall Mars would be most similar to Earth, relative to the amount of radiation recived in terms of seasons and Neptune would be the most different. Since the other planets, esspecially Neptune reciere much less solar radiation their seasons will be less extreme than Earth so it may be hard to tell when the planet is experiencing a different season, the time periods of the seasons are also longer than Earth, and are depondant on the orbital period of the planet.

2 *This might change during EL Nino as there would be strong westerlies at New Zealand and less north eastrly. Additionally, the water temprature would be cooler as the warmer water is nearer South America. This could reduce water tempretures near Chatum Rise.

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

93104