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SCHOLARSHIP EXEMPLAR

NZQA | Mana Tohu Mātauranga o Aotearoa
New Zealand Qualifications Authority

Scholarship 2023
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.

Show ALL working.

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 (AREA DO NOT WRITE). 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: PHYTOPLANKTON AND THE CARBON CYCLE

Discuss the significance of phytoplankton compared to plants in the global carbon budget.

In your answer, include how it could be affected by climate change, and how it could be enhanced using human intervention.

- The carbon cycle is a pivotal role in the example of phytoplankton. as the organism ~~is~~ as it a biological pump in the realm of the carbon cycle, ~~it~~ will absorb carbon based compounds and conduct photosynthetic reactions to produce simple sugars as well as O_2 that can be released back into the atmosphere:
(carbon dioxide + water (light energy / sunlight) → glucose + oxygen).
- The carbon cycle as it has two pumps (Biological and physical pumps) will allow for CO_2 for it be best dissolved in cold water rather than warm water as it will release it back at into the atmosphere. The biological pump - phytoplankton will absorb the CO_2 and produce glucose ($C_6H_{12}O_6$) + oxygen via photosynthesis and can die off and fall as marine snow onto the oceans floor. However in context, phytoplankton have been in interest with whales which consume tons of phytoplankton and will eject waste / faecal matter that is enriched with nutrients and float to the sea floor where ~~eggshin~~ can form limestone. and or the decomposition of whales when they die and a large amount of their matter floats to the sea floor can also form limestone. (Continued on next page)

- When it comes to plants / organisms that photosynthesise on land it is said that although there is less mass overall of phytoplankton as there is to trees and other vegetation (100 times less overall). The phytoplankton undergo

a rather similar amount of photosynthesis to vegetation on land. This could indicate that at a larger rate / mass of phytoplankton they can photosynthesise and produce more oxygen than trees. It is also said that phytoplankton consume around 10 times more CO_2 than is released by humans annually via fossil fuels indicating that again they can photosynthesise mass quantities of carbon dioxide in oxygen.

- When it comes to the global impact and carbon budget discussed. Which measures how much carbon is entering and leaving the atmosphere. We can take into consideration the amount of carbon that enters the deep oceans, which in some cases it can fluctuate between 1% of the total phytoplankton, however it can go to around 50%. ~~when~~ in highly productive areas that contain algae Bloom. Which seems to be consisting of phytoplankton as well as high levels of algae. This means as it goes with their belief the global carbon budget should consider variables such as the algae bloom and the rates of photosynthesis with or without these conditions. However it is also important to consider the rate or possible photosynthesis of this phytoplankton at the algae bloom as when the populations were very high it led to more toxins and lack of oxygen being produced / built up. This is because there is too much that could compete for the CO_2 absorbed in the water, meaning, that some will die off and there will be a decrease in rate of photosynthesis if there is an abundance of phytoplankton in these algae blooms

- Another organism that eats phytoplankton was the zooplankton and alike to the whales that ~~pre~~consume phytoplankton, they can release waste that can sink. ~~Their~~ Their bodys can die and natrally be decomposed by bacteria for energy. But also their carbon rich bodies sink to be stored as limestone or deepsea currents.

- Possible considerations of potential influences that could negately impact the phytoplankton is global warming and considering the melting of polar ice caps that could potentially harm our oceans process of absorbing CO_2. This is because in the oceans it requires cold water to absorb CO_2 rather than warm water (physical pump) otherwise it will be ejected back into the ~~space~~ atmosphere. But global heating and the warming of the oceans are influenced by the albedo effect which is the reflectivity of the suns radiation. As to consider is that at the ice caps as the surface is white (of ice) it can reflect around 90% of the suns radiation while 10% is absorbed. However the oceans can absorb around 94% of the suns radiation hence it can heat up the oceans, which can melt the ice. and the cycle can continue forming a positive feedback loop. as the oceans continue to heat less and less CO_2 can be absorbed into the ocean ~~meaning that~~ plus since the ice is starting to melt, if ~~it~~ sea ice finish melting and land ice continues to melt then it can dilute the salinity of the water, plus the temperate can increase.

both cases can harm our thermohaline ~~current~~ circulation. this is where cold water downwells nutrients and will cycle around the equator and upwells nutrients (CO_2). So if oceans be less likely to absorb CO_2 because oceans are heating up plus the consideration of the lack of transport that more phytoplankton will have less food, and die, and the global climate will continue to increase.

- The other consideration was the oceans continuing to acidify. where CO_2 dissolved can harm shell forming organisms as CO_2 can react with water to produce Bicarbonate ions, which can destroy their shells, and ultimately decrease the pH of our oceans. This is likely influenced by the lack of phytoplankton that is there to photosynthesise the CO_2 in the oceans, before it reacts with water to form Bicarbonate → Hydrogen ions.

- So in terms of how to enhance the potentials and benefits of phytoplankton, inorder to reduce the implications of ocean acidification and the warming of oceans. In N2 we can cipher new methods to reduce potential greenhouse / fossil fuels / gases, so as there is less of an abundance, that is competed for and contributing to global warming. This could be the potentials of reducing fossil fuel emissions / burning that creates plumes of smoke / Co2 and soot / or eco / greener ways for farming so less methane is released in the air as methane is a main contributer for global warming, even more than carbon.

QUESTION TWO: SLOW-SLIP EVENTS

Explore the differences between earthquakes and slow-slip events, referring to the Eketāhuna and Kaikōura earthquakes.

In your answer, include how the information collected by geologists can help further their understanding of slow-slip events, and the difficulties with monitoring on land, and at sea.

- When it comes to the differences between earthquakes and slow-slip events; Earthquakes are an event where there is a moment of a sudden release of copious amounts of energy, this is based on the friction and not that is stored, that could be placed on the fault. especially in the instance where the australian and pacific plate were locked together de to friction, and hae a release of energy. This is subduction, which is the process of convergence / collision where two plates will converge and in this instance the pacific plate will subduct under the australian plate, and are "locked", This process can bring down water under with it and can heat up the water which can melt surrounding rocks to form magma. This process of an earthquake could potentially trigger a slow-slip event.

- Slow slips however when an amount of energy is released over a longer period of time, in a older area. this means as the plates move past eachother, this process can occur over the span of days and months. Which can also trigger potentially an earthquake in other regions. So in the example off the east coast (Pōrangahau) in 2006, 2011 & 2016. Scientists when measuring indicated a 2cm movement eastwad, this means through Pōrangahau & towards gisborne, there was the moment where Australian and the pacific plates

moved past eachother rather than subducting under one and another with a slow release of energy. (days/weeks/months). One key thing to consider is that slow slips triggered (in 2021) a series of clusters of 60 small earthquakes (of a 4.2 magnitude) that reached towards the north of Gisborne. This means that the potential ~~energy~~ energy from the friction and heat, travelled up the plate, to regions where plates may have subducted and released the energy in triggering these earthquakes.

-Another example to consider is the post earthquake of 2016 the Kaikōura earthquake + the Malboraugh afterslip. (Malboraugh - event that was post earthquake). This earthquake possibly could have triggered (even though 600km away) the potential Malboraugh after slip and as geologists believed that the event that ~~happened~~ started in 2013 (in the east coast) also triggered. (afterslip) a 6.2 magnitude earthquake Ekefahuna in 2014. So the slow slips identified shared a rather slow release of energy that somewhat lasted a year on average, caused a sudden release of energy as an example of the 6.2 magnitude earthquake, as well as the post earthquake slip of Malboroygh that was possibly triggered by the Kaikōura earthquake. These are examples of how earthquakes and ~~stops~~ Slow-Slips can trigger one an another, as well as their potentials on how much energy the release and how quickly it is released, whether its via subduction plates locking or plates gliding along eachother over a ~~short~~ longer period of time.

- When looking into potentials on how to analyse and observe slow-slip ~~earth~~ events. It is mentioned that places such as Hikurangi Subduction Zone, used GPS stations that were placed on land to measure the displacement of movement, as slowslips because of their long term release cant be detected off of Seismometers. These GPS placements followed the plate boundary along the East of NZ. This is used to observe pictures in the different stages of movement inorder to deduce a possible rate of movement.

- But also they placed pressure sensors on the seafloor to detect any "vertical movement" as the seafloor changes in response to the changes on the water column above. So if ~~a slow-slip need to occur~~ Plates were to subside then. beneath the sensors the seafloor is expected to rise. However they identified that the sensors registered a decrease in pressure! (if there was an uplift.) They identified that slow-slip events that we recorded were further away from New Zealand. So what was identified via this method does indicate that ~~these~~ if there was an uplift of the seafloor the pressure would decrease as a result as energy is released. However if the seafloor subsided then it is likely the plates subducted under another hence allow friction and pressure to increase. So this method supports the two possible events, ~~however there still is the question on~~. So in terms of both methods they both provide a perspective of

both earthquakes and slow-slip events, ~~from~~ from a vertical and horizontal movement observation. from ~~However there is a concern still that doesn't support~~ whether slow-slip events and earthquakes can cause one and other, as we go off of the evidence recorded and our pre-existing knowledge there is no ~~link into how one event may trigger~~ the other.

a sea and land perspective.

- In tems of monitoring and its potential difficulties. Somethings could arise is the abilty to maintain the equipment as slow-slips for example may as aforemented last (days/weeks/or months). So there would need to be constant surveillence on the equipment used, especialy if it is underwater. But also in tems of Earthquakes there is the potential of destruction of equipment meaning that as it can release sudden amounts of energy-quicky and largely, there are possibiltjes of damange, and mantinence,

- But also as these slow slips events are regulaly occuring. it may also require content monitoring and surellence so that we could correlate the potentials of slow-slips triggering earthquakes or vice versa.

~~- Richter scales~~

QUESTION THREE: JUPITER'S ATMOSPHERIC CELLS

Analyse the differences between the Earth's atmospheric cells and the bands on Jupiter. Explain why these differences occur, and how these relate to the size, rotational speed, and composition of both planets.

In your answer, include a comparison of the depth of the cells between the two planets, and discuss the significance of the Giant Red Spot.

- Atmospheric cells on earth are a product of hot/warm air being ejected out of the equator, and will ~~Red~~move outwards away from the equator and cool down as it falls back to its surface, this will cycle back and the process will continue, this being an indicator of a closed system. The reason why ~~is because~~ the equator has warm air is due to uneven heating on the earths surface this is because of the earths axial tilts (23.5°) which results in uneven heating in regions such as the equator, where it will be warmer, and colder in the polar regions. These cells will curve in alternating directions due to the coriolis effect which is ~~the~~ produced via the rotational speed differences that occurs between latitudes, where it will have high pressure in places such as poles and low pressure at the equator. This will contribute to the curvature of wind patterns. Considering Earth is a rocky planet it will have a crust a semi molten ~~Jupiters~~ core that rotates as well as a crust, ~~Mag~~ ~~netos~~ as well as factors such as water and the potentials of plate tectonics and an atmosphere. Because of such factors.

- Jupiter on the other hand is a gas giant meaning that in its formation past the protoplanetary disc formation, gases such as Hydrogen and Helium

created the gas giant, rather than rocks and masses to form a rocky planet. Also jupiter has a rather low axial tilt of (9° approx) meaning that there will be less uneven heating on the gas giant, which indicates it will not have the potential to have atmospheric cells that are a closed system. (Meaning they don't cycle back, once ejected out of the equator). Also jupiter as it has an 11 times bigger radius than Earth and being 1321 times bigger than Earths value (of 9.925 earth mass). will indicate for a faster rotational speed. which can account for very fast winds, and because of its size being so large it can have a large amount of gravity. And because of the different rotational speeds it can account for many winds to go in alternating directions along the circulation cells. Unlike to what earth has jupiter has Jovian bands and Belts, the light bands being zones of rising gases. and the Belts that are darker represent the sinking gases. What is notable about these bands is that they when observed by Juno (a spacecraft) are like jetstreams meaning that they extend way far (3000km) from the planets atmosphere, and contain Ferrell like cells, which to Earth are located closest to the equator (0° - 30° latitude). This is because of the vertical convective motion (which is the transfer of heat via gases. This is because of the upwelling gases (warm). that indicate the lighter layers and the colder gases that downwell back to its surface being the darker bands. This is refining the understanding

That the movement of gases in the giant (gas) jupiter is a closed system.

- A final difference to Earth that jupiter has is the recognisable red spot on the southern Hemisphere of the planet. This is identified to be a giant storm that has lasted 500 years. This considered similarly to earth is defined as an anticyclone, which is a storm located in the Southern Hemisphere of a planet rotates in the opposite direction (anticlockwise) to a cyclone (clockwise). This could be the potential influences of the ~~guide vanes~~ cells of jupiters rotational speed that accounts for anticlockwise rotation of the cyclone. As they have Ferrell like cells that on earth are usually located on latitude (~~5~~ 30°-60°) it can contribute to the possible anticlockwise direction that occurs alike to Earth's.

- The depth of the cells between the two planets is indicative that the cells located on jupiter are extensive to lengths of 3000km. ~~than~~ Accounting for also the many cells (Ferrell like) ~~that not~~ Both on the norther and southern Hemisphere having 8 cells each. The reason why jupiter could release higher depth cells is because of the potential energy that it releases from its surface. This energy that should arginate from the Sun, is more recieved on Jupiters surface despite its distance, to that of Earths. (Jupiter receiving more solar energy than

Composed to earths 6 cells Hadley (0-30°), Ferrell (30-60°) & Polar (60-90°)

earth.) and via convective motion it can release the cells higher than Earths. which although closer to the sun, recievs less solar energy, which results in less energy released from the equator. Also as Jupiter is a gas giant it also produces more thermal energy, and accounting for its size and its gases associated (H & He) it can release ~~an equal~~ more energy. than earths, which is a rocky planet not a gas giant that could make its own heat energy.

- The Red spot as its an anticyclone, (a cyclone that rotates in the opposite direction to a cyclone). Which could indicate becaus of the winds in the cyclone, that water vapor exists (Rather than oceans). possible frozen or shards of ice, may circulate in the spot, and travel around the planet via cells to slowly cooldown the planets surface. So as heat energy is released and. as well as heat energy being recieved from the sun, the Red spot could indicate. a method of cooling via ~~frozen ice that~~ water vapour that could be dispersed. to slowly cool the planet down.

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

QUESTION NUMBER

1) Another potential to maximise photosynthesis of phytoplankton is to possibly establish new farms of phytoplankton in areas around NZ, with the potentials of algae Bloom as they have 50% in high productivity rates. But enough of a population where they can respire without competing for CO_2 absorption. This can also contribute to the potentials of Ocean acidifican and warming of oceans.

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

QUESTION NUMBER

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QUESTION NUMBER

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Subject	Earth and Space Science Scholarship Scholarship	***Standard***	93104	***Total score***	15

Q	***Score***	***Annotation***
1	5	Candidate has explored the carbon cycle and related it to the context of the question. Furthermore, they have explored effects on the carbon cycle particularly mentioning how thermohaline is affected. Better comparison of the significance of phytoplankton with plants was required to be awarded a higher grade.
2	4	Candidate explored the links between slow-slip events and sudden release earthquakes and the issues with monitoring of these events. It was not awarded higher than a 4 because there was some rewording of the resource material which limited their answer.
3	6	Candidate has analysed the differences between the formation of the cells on Earth compared to Jupiter. The answer was well written which is why it is a 6 as they presented some good analysis. However, they did not explore the significance of the Giant Red Spot well enough to be awarded a 7.