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NEW ZEALAND QUALIFICATIONS AUTHORITY
MANA TOHU MĀTAURANGA O AOTEAROA

QUALIFY FOR THE FUTURE WORLD
KIA NOHO TAKATŪ KI TŌ ĀMUA AO!

Scholarship 2015
Earth and Space Science

2.00 p.m. Tuesday 1 December 2015

RESOURCE BOOKLET

Refer to this booklet to answer the questions for Scholarship Earth and Space Science 93104.

Check that this booklet has pages 2–7 in the correct order and that none of these pages is blank.

YOU MAY KEEP THIS BOOKLET AT THE END OF THE EXAMINATION.

Resource for
QUESTION ONE: RECORDS OF THE PAST IN OCEAN SEDIMENTS

Use this material to help you answer Question One on page 2 of your exam booklet.

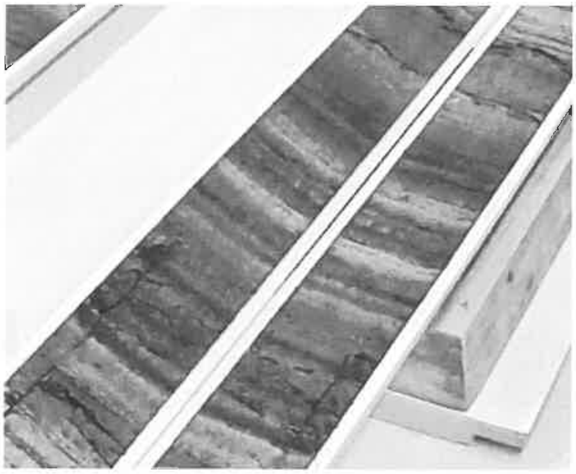
Sediment cores sampled, for example, from the deep ocean off the east coast of the North Island, give a record of the geological, biological, atmospheric, and climatic changes of New Zealand's dynamic marine and land environments over many thousands of years.

Sediment from the land, such as soil particles from erosion and plant pollen, reach the ocean by wind or water, and are then dispersed by waves, currents, and tides. Larger particles such as sand are deposited near the coast, and smaller particles such as clay and silt are transported further off shore before they settle to the bottom.

Marine plants and animals contribute to the sediments in the form of marine snow – the remains of dead and decaying marine organisms, and faecal pellets, which gradually sink onto the ocean floor. Much of the marine sediment is composed of the remains of different types of phyto- and zooplankton, such as the tiny calcium carbonate or silicate skeletons of coccolithophores and foraminifera. These are highly sensitive to changes in oceanic conditions such as temperature, pH, nutrients, and dissolved gases like oxygen and carbon dioxide.

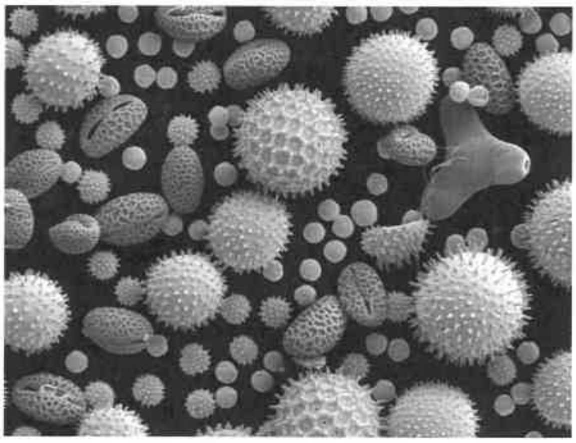
Oxygen and carbon have stable isotopes that can be analysed from sediment samples. Oxygen has O-16 and O-18, and carbon C-12 and C-13. The ratios of these isotopes can vary over time, and indicate climate changes.

- Heavier isotopes such as O-18 are less likely to be evaporated when part of a water molecule.
- Photosynthesis increases the ratio of C-12 to C-13 stored in plants, affecting the proportions of these two isotopes in the atmosphere.
- Carbon dioxide is dissolved in the ocean at the C-12 to C-13 ratio of the atmosphere at that time.



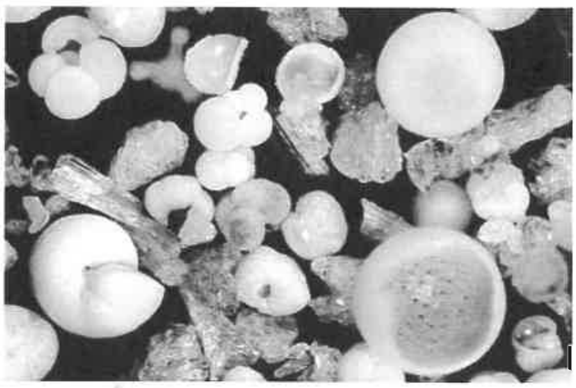
Layering in a sediment core.

http://juliansrockandiceblog.blogspot.co.nz/2014/10/natures-seismometers.html



Pollen grains showing the range of variation between different species of plants.

http://upload.wikimedia.org/wikipedia/commons/2/2a/Misc_pollen_colorized.jpg



A sample of sediment showing the shells of the zooplankton foraminifera plus grains of rock.

http://www.teara.govt.nz/en/photograph/5613/foraminiferous-sediment

Resource for

QUESTION TWO: CHANGES IN ATMOSPHERIC CIRCULATION IN THE SOUTHERN HEMISPHERE

Use this material to help you answer Question Two on page 6 of your exam booklet.

Over the last few decades, the rising concentration of greenhouse gases (GHG) and the depletion of the ozone layer (forming the "ozone hole") over Antarctica have affected the overall temperatures in both the stratosphere and troposphere and caused a change in the pressure gradient between mid- and polar latitudes in the Southern Hemisphere.

This has resulted in changes in the Southern Hemisphere's atmospheric circulation, especially the position of the southern boundaries of the Hadley, Ferrel and Polar convection cells, the prevailing westerly winds, and the westerly polar jet stream.

- Greenhouse gases include carbon dioxide (CO_2), methane (CH_4), water vapour, nitrous oxide and human-made ozone – a pollutant. GHG accumulate in the troposphere.
- Ozone (O_3) is a gas that is naturally formed and destroyed in roughly equal amounts by UV radiation from the Sun. The ozone forms a layer in the stratosphere that retains heat by absorbing the Sun's UV radiation.
- The ozone hole is formed when ozone is broken down by ozone-depleting chemicals such as human-made chlorofluorocarbons (CFCs), which have been carried up into the stratosphere by upward moving air currents. International treaties have now prohibited their use, but CFCs are very stable and will remain in the stratosphere for long periods of time. The ozone layer is expected to recover later on this century.
- Severe ozone depletion (the ozone hole) occurs in winter and spring over Antarctica. When winter arrives, strong winds develop around the pole and isolate the polar stratosphere. Polar stratospheric clouds (PSCs) form at very low temperatures and have an icy surface on which chemical reactions occur that destroy ozone. Ozone levels in the stratosphere return to normal in the summer.
- The Polar Jet Stream blows from west to east at about 70°S, just beneath the tropopause.
- Cooling in the stratosphere causes expansion of the troposphere, both vertically and horizontally.
- The Antarctic Circumpolar Current in the Southern Ocean, along with the belt of westerly winds, is a strong barrier to heat moving southward from the Equator.
- Atmospheric pressure difference between the Southern Hemisphere mid-latitudes and Antarctica is variable. A greater difference in temperatures across the Southern Hemisphere leads to greater pressure differences.
- The temperature in Antarctica can reach as low as –89°C.

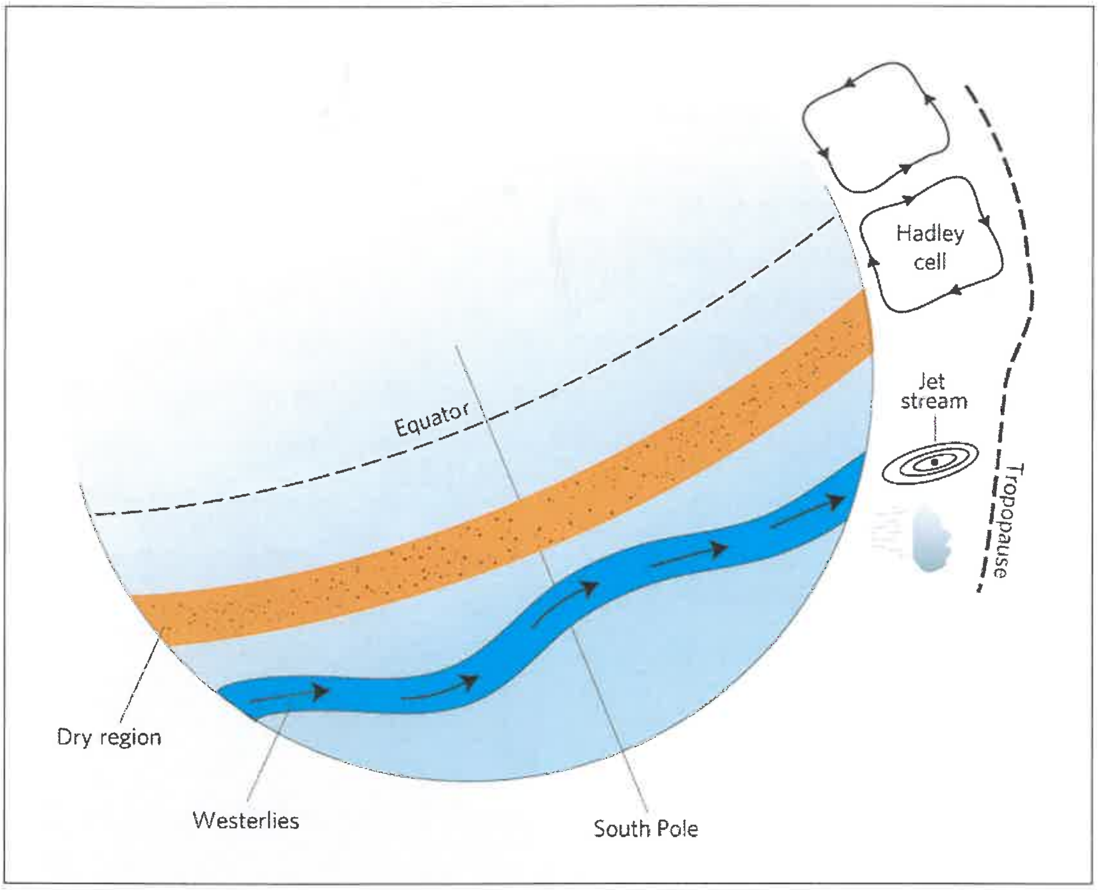


Diagram showing key parts of Southern Hemisphere atmospheric circulation.
www.nature.com/nclimate/journal/v1/n1/fig_tab/nclimate1065_F1.html

Polar Stratospheric clouds.
http://en.wikipedia.org/wiki/Polar_stratospheric_cloud#mediaviewer/File:Nacreous_clouds_Antarctica.jpg

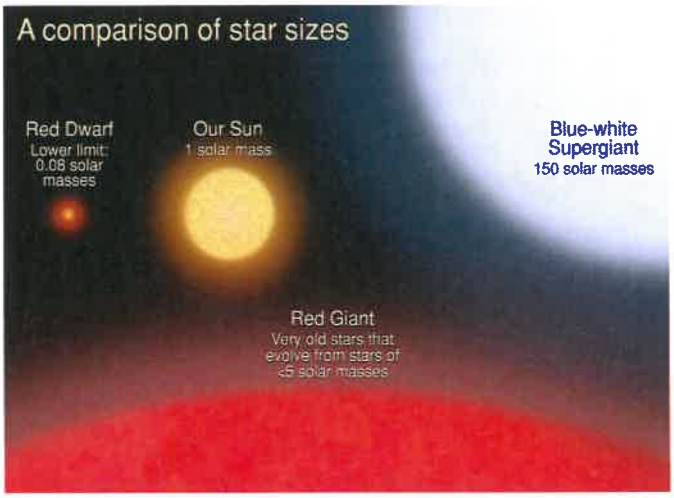
Resource for
QUESTION THREE: HABITABLE ZONES AROUND RED DWARF STARS

Use this material to help you answer Question Three on page 10 of your exam booklet.

One astronomical unit (1 AU) is the average distance from Sun to Earth.
The mass of the Sun is one solar mass or $1M_{sun}$.
Zero degrees Kelvin (K) = –273 degrees Celsius (°C), 0°C = 273 K.
The melting point of water is 0°C and that of methane is –183°C at one atmosphere pressure.
The boiling point of water is 100°C and that of methane is –161°C at one atmosphere pressure.
The Sun's surface temperature is about 5800 K, and that of red dwarf stars is about 3000–4000 K.

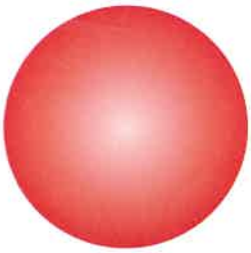
Possible planetary zones around red dwarf stars are being searched for planets that may have life. Red dwarf stars make up at least 70 per cent of the stars in the universe. They are up to 50 times dimmer than the Sun and less massive, which makes them relatively cool.

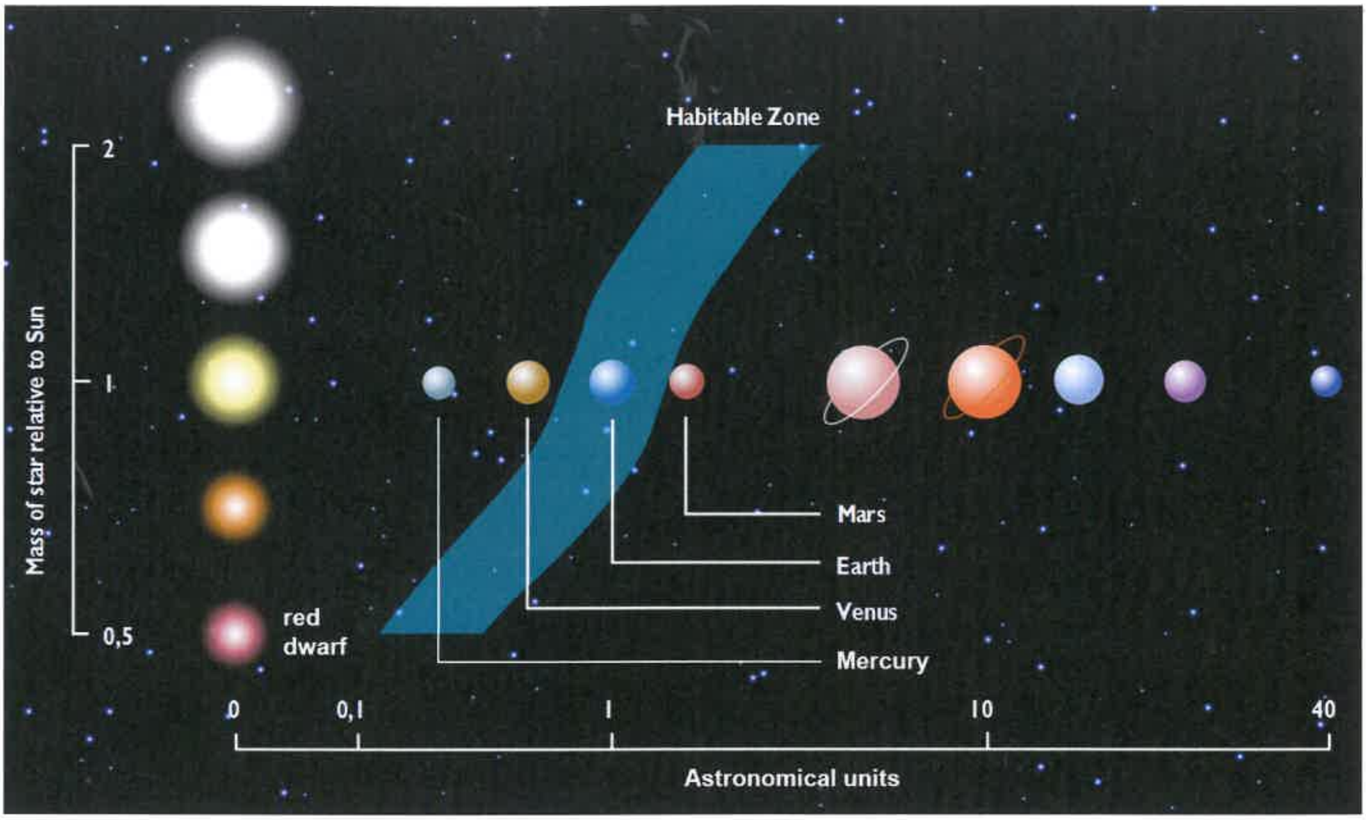
Their small mass means that they fuse hydrogen to helium very slowly and therefore they live for trillions of years before running out of fuel. At least half of these stars may have rocky planets orbiting them with a similar mass to Earth.



Relative sizes of different types of stars.
http://cdn.spacetelescope.org/archives/images/screen/opo0505b.jpg

The stages in a red dwarf star's formation:

1. Clouds of dust and gas collapse and compress under their own gravity and start to rotate.	2. A proto-red dwarf star heats up in the middle, and surrounding matter forms planets and moons.	3. A pre-main sequence red dwarf star forms when the star has all of its mass, but fusion hasn't yet begun. Red dwarfs could be in this stage for up to 2.5 billion years. Life may begin evolving during this pre-main sequence stage	4. A main sequence star forms when hydrogen starts fusing to helium releasing vast amounts of energy. As a red dwarf ages, it shrinks even further.
Relative size of the developing red dwarf			



The habitable zone around stars of different mass for water to be liquid.
http://l2udsyear2013114.pbworks.com/f/1395593266/3habitable_zone-en.jpg

- Planets or moons that are close to the star or planet that they are orbiting become tidally locked. This means that they take just as long to rotate around their own axis as they do to orbit their star or planet. One side constantly faces the star or planet respectively. For example, the same side of the Moon always faces the Earth.
- The younger the star, the more active its surface is. Solar flares may erupt from the surface several times a day, causing ultraviolet radiation to rise to high levels. Stellar wind, a continuous flow of charged particles streaming from the star in all directions, causes extreme space weather.
- Earth is 4½ billion years old. Life probably began evolving about 4 – 3½ billion years ago.