Grade 12 Earth and Space Science

SES4U

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Contents

Chapter 3

Earth's Material & Geological Process

3.1 Documentary

1. The oldest objects in the solar system are **meteoroid**
2. The first rock to form on the Earth was **besalt**
3. Nature's physical building blocks are **minerals**
4. The foundation of the continents is what type of rock? **Granite**
5. One of the longest-lasting materials in nature is the gemstones **zincons**
6. The building blocks of life are **amino acids**
7. The first fossilized remnants of life found in the ancient rocks of Australia are called **stromatolites**
8. Photosynthesis led to the rise of the levels of **oxygen** gas
9. Today there are more than **5000** minerals on Earth
10. Trilobites are found as fossils today because of their **shells**

3.2 Rock cycle and Identification

3.2.1 Introduction to rock

Sedimentary Rock

Sedimentary Rock: Generally form from the compaction and cementation of sediments

Now here we have two different categories

Clastic: compacted sediments, classified by size. ex. Sandstone, conglomerate, siltstone

Organic or crystallite

- Evaporites
- Precipitates
- Biological matter ex. limestone

Metamorphic

Metamorphic Rock: Rocks that are changed as a result of intense heat and/or pressure

Contact metamorphism: Heat ex. schist, gneiss, marble

Regional metamorphism: Pressure

Igneous

Igneous Rock: Form from the cooling and solidification of lava or magma.

Intrusive: Formed from magma that cools and solidites underground

- Magma cools slowly
- Large crystal formed

Extrusive: Formed on the surface of Earth from lava.

- Lava cools quickly
- small or no crystal
- May be visiculars (Contains air bubbles)

3.3 Mineral Identification

Density

Steps to determine the density of a mineral:

1. Use a balance to weight its mass (in kg)
2. Fill a graduate cylinder with water, throw the mineral in to see how much the water rises in a graduate cylinder. (in mL)
3. Calculate $\frac{\text{mass}}{\text{volume}}$

How "light" or "heavy" an object is for this size.

Crystal

Minerals are amde of atoms in a repeating pattern and often from crystal

Possible options:

- Hexagon
- Cube
- Pyramid
- Rectangle

Luster

Luster is the way the mineral's surface reflect light.

Hardness

Hardness is a measure of how easily a mineral can be scratched. It is measured on a scale of 1 to 10 called Mohs scale.

Streak

The Streak is the color of a material's powder.

Remark. If the mineral is harder than the streak plate, it won't leave a streak.

Acid test

Some minerals cause hydrochloric acid to bubble and fizz.

3.4 Earthquakes

3.4.1 Terminology

Definition 3.4.1 (Focus)**.** *Where the earthquake starts.*

Definition 3.4.2 (Epicentre)**.** *The location on the surface directly above the surface.*

Definition 3.4.3 (Seismographs)**.** *Instrument used to record the motion of the ground during an earthquake*

Definition 3.4.4 (Seismogram)**.** *The graph which is recorded by the seismograph*

The tools can allow us to measure the intensity of earthquakes! The scale that is commonly used is called the Richter Scale

The scale involves measuring the amplitude of the largest wave at a specific distance from the epicentre

Remark. Ricter Scale is a quantity way to measure the magnitude of the earthquake. (An open-ended scale) Mercalli Scale is used to measure the intensity of the earthquake. (A closed scale)

3.4.2 Waves

These waves are ranked by their speed:

Body wave

Definition 3.4.5 (P-Wave)**.** *Parallel to the direction of the wave (forward + backward)*

Definition 3.4.6 (S Wave)**.** *Perpendicular to the direction of the wave (side by side)*

Surface wave

Definition 3.4.7 (Love wave)**.** *Like water wave*

Definition 3.4.8 (raylight)**.** *Rotate under ground*

3.5 Unit 3 - seminar Testable Question

3.5.1 Formation and Identification of minerals

Question 1

What is the definition of a mineral?

A solid inorganic substance that occurs naturally

Question 2

Explain streak, hardness and cleavage/fracture

- Streak: Used to determine the color of mineral in its powdered form, test by rubbing the mineral against a streak plate
- Hardness: use Moh's scale of hardness, compare hardness of an unknown minerals to the hardness of 10 known minerals and/or to the household objects
- Cleavage/fracture: different minerals break in different ways depending on their atomic structure.

3.5.2 Gemstones

Question 1

The disadvantage iof Chemical Vapor Deposition(CVD) diamonds?

Takes much more time to produce compared to a High Pressure Temperature (HPHT) diamonds

Questoin 2

Application of diamond:

- Nanodiamonds: The super small diamonds that aloow for many medical implication
- dental implants

Question 3

Blood diamonds:

- Mined in areas controlled by forces opposed to a country's government
- Sold to fund military action against that government
- Often extracted under conditions of forced labor

3.5.3 Marine geology - Deep sea sedimentation

What is a sedimentation?

- The settling of solid particles in fluid

What can sediments tell us about Earth's past climate?

- Past temperatures, climate and rainfall.

3.5.4 Investigate technologies to predict earthquakes, volcanoes and tsunamis

Which of the following gas are most often used when predicting volcanic eruptions?

- Sulfur Dioxide

Describe how the use of interferometry by Synthetic Aperture Radar (SAR) satelliets might help to detect earthquakes?

1. Interferometry takes two or more images of the same area of the Earth at different times
2. Analyzed for changes between images
3. Changes could be signs of an earthquakes

3.5.5 Investigate the Canadian Lithoprobe Project and how it enhanced our understanding of the Earth's interior.

What was the main goal of the Canadian Lithprobe project:

- To map the deep structure of Earth's crust using seismic technology

Which technology was most important in helping Lithprobe "see" inside of the Earth?

- Seismic reflection and refrection surveys

The Canadian Lithoprobe Project helped scientists to better understand Ancient Continental Collisions

3.5.6 Investigate the structural engineering techniques and advance technology used to build earthquake-resistant infrastructure

1

What materials are base isolators typicall made out of?

- Lead, rubber, steel

2

How to turned mass dampers protect a building during an earthquake?

- It opposes the motion of the structure by swinging in the opposite direction

3

Why is steel typically added to concrete when structures are constructed?

- Concrete in strong under compression but weak under tension
- Adding steel allows it to bend without breaking during earthquakes

3.5.7 How have Earthquakes and volcanoes affected the development of cities?

According to the case study, what was the primary phenomenon that caused extensive damage in Christchurch, New Zealand, other than the seismic waves?

- Soil liquefaction

2

Explain the fundamental difference between "brittle failure" and "ductile design" in building materials when faced with seismic stress.

- Brittle failure occurs when rigid materials shatter or crack suddenly under stress
- Ductile design allows materials to flex and bend without breaking

3

For the "Earthquake Early Warning" (EEW) system, explain how it works, and a key limitation:

- Its primary function is to detect the fast P-waves to provide a warning to the public before the damaging S-waves arrive
- It provides a relatively short warning

3.5.8 Minerals and human health

What is hard water?

- Water containing high concentrations of dissolved minerals

Where does it come from:

- When rainwater, which is slightly acidic, filters through the ground, it dissolves minerals, which then goes into the groundwater

3.5.9 Critical minerals

List the four most important sectors that require critical minerals?

- Electronics, renewable energy, medical devices, military defense

Define "critical Mineral"

- Elements and compounds that are essential for modern technologies
- Face a high risk of supply chain destruction due to factors like rarity, geographical concentration, or geopolitical issues

Production of critical minerals

- Upstream: extraction
- Midstream: Processing and refining
- Downstream: recycling

3.5.10 The geological composition of famous buildings and landmarks

What makes ancient Roman concrete special?

- Primary binding agent in the concrete was a mixture of lime and volcanci ash, which helped to give it self-healing abilities

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Explain how and why limestone and granite was used in the Pyramids:

- Limestone
-
  - Makes up most of the outer layer to make the pyramid smooth and shiny
  - Relatively easy to quarry and shape
- granite
-
  - Makes up the internal structural elements
  - Used for its strength and status
  - More difficult to work with

3.5.11 Mining technologies

Two important methods of surface mining extraction

- Open pit mining: a mine is dig out on the ground's surface
- Quarrying: A type of open pit mine that primarily extract rocks

Sub-surface mining extraction method:

- Block Caving
- Ore deposit is undercut at different weak points
- The ore body then collapses under its own gravity into drawpoints where minerals are collected and transported

3.5.12 Oil and natural gas

Core mechanism of a seismic survey?

- Emitting vibrations into the ground and recording the reflected waves from rock layers

Key process that controls whether hydrocarbons become oil or natural gas?

- Kerogen breaks down into oil at lower temperatures and shallow depths
- Natural gas is produced at much higher temperature and deeper depth

temperature-controlled distillation

1. Crude oil is heated until it vaporizes
2. The hot vapor enters a distillation tower, where the bottom is very hot and the top is cooler
3. Light hydrocarbons rise higher in the twer, heavier hydrocarbons stay lower

3.5.13 Asteroid mining

Karman+'s long term plan after they mine materials from asteroids?

- They want to build and sustain things in space, where things like manufacturing and fuel production happens there.

What is a carbonaceous asteroid?

- The asteroid is rich in hydrated clays

How do catalytic converters in vehicles help with air pollution caused by vehicles?

- They reduce pollutants such as carbon monoxide and hydrocarbons by converting them into less hamful gases

3.5.14 Weathering and Erosion

How water can cause both mechancial and chemical weathering in the same rock at the same time.

- Mechancial - Water can physically break rock by freezing and expanding in cracks
- Chemical - Water can react with minerals and/or dissolve them

If there are two of the same type and size of rock, why does the rock with more surface area experience faster weathering?

- Because more of the rock is exposed to weathering agents like water, air and acids