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PSG PROGRAMME (NCQF LEVEL 5).

MODULE 3.

- **OBJECTIVES** (3.1)

- **On completion of this module you will:**
  - Know what the meaning of Geology is.
  - Have a basic understanding of what the Earth consists of.
  - Know how rocks are classified.
  - Understand how igneous, sedimentary and metamorphic rocks are formed.
  - Know what a mineral is and be able to give a few examples.
  - Have an understanding and knowledge of a few common rock types.
  - Have an understanding of the interrelationships between rocks, soil, climate, vegetation and animals.

The Basic Dynamics of Geology (3.1.1).

What is Geology?

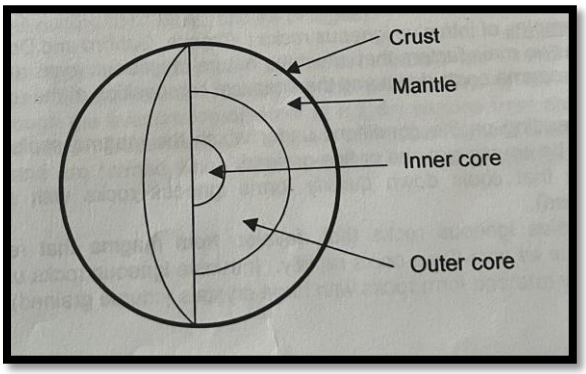
- Geology is the study of the rocks and processes of the earth, and it`s history. A knowledge of geology is important to us (Nature Guides), because the rock formations of our earth are the foundation of the landscape of the environment and of life on earth. Rocks are the basis of the landscape of the earth`s surface, and the natural processes of the earth gives earth its special environmental character in the Solar System. From rocks soil is formed, which gives life to plants, and plants in turn gives life to animals and people.

- In order to understand our environment, we must become aware of the interaction and interrelations between living organisms, and between living organisms and their environment. The rock formations and the processes of our earth represent the beginning of many interrelations that culminate in ecosystems. It is important to bare in mind that when we speak of geological history, we certainly speak in terms of millions and thousands of millions of years. In the lifetime of a human one will notice little difference in the appearance of the earth, but in a million years many things happen. Some natural processes, however act over a short period of time, such as volcanic eruptions, rock falls or tidal waves etc.

Basic Composition of the Earth (3.1.2)

- At first; one needs some understanding of the composition of the earth. The earth`s interior consists of different layers of rock, all in varying degrees of solidity. On the outside we have the rigid crust of the earth - 15 to 55km deep in places. At the base of the earth crust the rocks are already red-hot, but not necessarily molten. The crust **floats** on the plastic mantle, which is about - 2900km thick. The core of the earth consists of a liquid outer core with a thickness of - 2300km, and a solid inner core with a radius of - 1100km.

- **Diagram of Earth`s Structure:**



- The fluid to plastic nature and high temperatures of the interior of the earth ensure that various kinds of convection currents are set up inside the earth, In other words, the inside of the earth is

not static, but a dynamic mass of plastic and molten rock with continuous movement. The crust of the earth consists of a series of relatively cold and rigid plates, which float on this mobile base. This results in areas where the crust of the earth cracks apart due to movements of plates away from one another (creating a valley), and in other places the plates collide - compressing the crust in one way or the other (creating ridges). These dynamic movements are the reasons behind the formation of volcanoes and earthquakes. Fractures of the crust usually provide the stimulus for magma (molten rock) to start moving upwards to the surface - forming Extrusive Rocks.

Minerals.

- What is the difference between rocks and minerals? Minerals are the building blocks of rocks, that is; rocks are made up of one or more mineral particles or crystals. Minerals are natural chemical compounds, each mineral having a specific chemical composition and a fixed in which its atoms (smallest particle) are packed together. Examples of common minerals are Quartz, which consists of Silicon Dioxide, Muscovite and Orthoclase Feldspar. There are about 1500 different minerals, fortunately only about a dozen are widely distributed in the rocks of the crust, the more exotic types occurring mostly in ore deposits. The common rock-forming minerals such as Quartz, Feldspar, Mica, Hornblende, Pyroxene, Calcite and others, occur in many combinations in rocks, but in practice there are probably not more than a dozen or so widely distributed rock types in the crust.

- Examples of common rocks are Granite - (mostly quartz, feldspar plus mica), Dolerite & Basalt - (mostly feldspar and pyroxene), Sandstone & Quartzite - (mostly quartz), Limestone & Marble - (mostly calcite). Take a good look at a freshly broken piece of coarse-grained rock such as Granite, - there are dark fragments, shiny fragments, sometimes green fragments or even white or pink fragments. All of these individual bits are minerals, - every rock thus consists of an aggregation of different mineral grains.

Basic Knowledge of the Rock Types (3.1.3).

- **Igneous Rocks** (the word igneous comes from the Latin name for fire). Igneous rocks are formed when hot magma (800 – 1300 degrees Celsius) cool down and solidifies under the surface of the earth and those are **Intrusive Igneous Rocks.** Because the cooling process is slow, their minerals tend to form large crystals – well drained and are difficult to weather. Granite and Gabbro are typical examples of intrusive igneous rocks with large crystals.

- Other magmas break through to the surface of the earth in the form of a volcano. The molten rock flows out as **lava** cools down. This type of igneous rock is known as **Extrusive Igneous Rocks.** The cooling process is very quick, and thus the crystals are much smaller – some lava looks like glass. Crystals in this lava are rarely larger than one millimeter in diameter. Basalt and Rhyolite are typical examples of extrusive igneous rocks.

- Comparing Granite and Basalt, we take note that granite magma in general originates from a depth of about 25km moving upwards into a zone of lower pressure, and started solidifying at a depth of

about 20km or even less. The product is a rock with large crystals and a mineral composition consisting of Quartz (about 60%), Feldspar (about 60%), and Mica (about 15%). Granite is a light-colored rock that is hard, tough and relatively resistant to weathering. Soils that develop from granite range from pale colored clayey and gritty (sandy) soils to freely draining sandy soils with coarse quartz grains. The chemical composition of the minerals results in a soil with low PH, meaning that it is acidic in nature.

- By comparison, Basalt magma in general starts to move upwards from a much greater depth, approximately 50km below the surface of the crust, and progresses all the to the surface of the earth, where it solidifies as lava, - becomes water logged and easily broken off. The crystals are microscopic (sub-millimeters in diameter) and the mineral composition – (Feldspar and Pyroxene in more or less equal proportions, with minor amounts of olivine, apatite and magnetite), has resulted in a dark colored rock that weathers easily. The weathered rock is normally stained reddish brown and it breaks down easily into a fine-grained dark clayey soil. The soil PH is high, which means that it will have an alkaline nature.

Sedimentary Rocks.

- Another major division of rocks in the crust of the earth is sedimentary rocks. These rocks form at the surface of the earth in a number ways. They are made up of sediments that originated through physical or chemical process or through the accumulation of organic remains. These sediments may then be buried, compacted and transformed into rocks. This process is known as **lithification.** For example, rivers can wash pebbles, grains of sand, clay and mud into the sea, where the layers of sediments are compacted and hardened naturally to form deposits of sedimentary rocks.

- Sediments can be detrital, meaning loose grains that can be carried by water streams, wind or other processes. Sandstone and Conglomerate are detrital sedimentary rocks. Sediments can be **chemical**, meaning deposits precipitated from solutions in surface water, pans and springs. Calcrete and Rock salt are examples of chemical sedimentary rocks. Some sedimentary rocks are **organic,** meaning they are deposits of plant or animal remains. Coal is an example of an organic sedimentary rock group. As a group they are characterized by being almost universally layered or bedded together. Except for rare types of chemical sedimentary rocks, the rest of the group of sedimentary rocks is characterized by the presence of grains or particles.

Metamorphic Rocks.

- The third division of rocks is called metamorphic rocks. Metamorphic means undergoing a change, this is exactly what happens here; one rock type has been changed into another. The change, **metamorphosis** is caused by one or more of the following:

    1. Increase in temperature (but not melting).

    2. Increase in pressure.

3. Activity of chemical solutions.

- Any rock can be metamorphosed and degrees of metamorphosis also exist, depending on the level of change in temperature and pressure, - and the length of time of this change in conditions. Invariably, metamorphosis is a process takes place well below the surface of the crust. The extent of metamorphic change ranges from very small (centimeter scale) to very large (100`s km scale), and the process can take millions of years to complete. Regardless of the extent of the metamorphosis the rock is never molten.

- Examples of common metamorphic rocks are Quartz – (from sandstone), Slate – (from shale), Schist – (from mudstone), Marble – (from limestone), and Gneiss – (from granite).

➢ **Contact Metamorphosis.**

- Contact metamorphosis is brought about by the heat of intrusions of igneous rock such as dolerite. Contact metamorphic rocks are commonly confined to the immediate vicinity of the intrusive rock that caused the rise in temperature. Contact metamorphosis can be seen in road cuttings that expose dolerite dykes/pieces penetrating sedimentary rocks.

- Examples of sedimentary and igneous rocks that became metamorphic rocks:

Sedimentary Rock	**Metamorphic Rock**
- Shale	Slate, Schist
- Sandstone	Quartzite
- Conglomerate/Breccia	Gneiss
- Limestone	Marble
- Bituminous coal	Anthracite/Graphite

Igneous Rock	**Metamorphic Rock**
- Granite	Granite Gneiss
- Rhyolite, Gabbro, Basalt	Schist

The Interrelationships Between Rocks, Soils, Climate, Vegetation and animals (3.1.4).

- Geomorphology is shaped by the underlying geology and it`s reaction to the climatic conditions of the area. Geomorphology is the way in which geology influences the shape of the landscape (visible features of an area of land). The geology influences the ecosystems that function in an area due to the wide variety of environmental conditions that develop. Rocks break down to form soils and the soil type is a result to the interaction of geology, climate and geomorphology.

- The type of vegetation that is found on the particular landscape is a result of the interaction between soil and climate. The animal species that are found in the different landscapes are there because the vegetation (food supply) is available and the climate suits them, - thus vegetation and climate will influence the animals found in the area.

Soils.

- Soils develop in two ways; that is in place directly from the mother rock or transported from elsewhere by soil creep, mudslides or by streams. Soil or pedological sphere may be defined as the weathered superficial layer of the earth`s crust that typically is made up of partly decomposed parent rock material with associated organic matter in various stages of decomposition. Because of the varying mineral composition of rocks, the type of mother rock is important in determining the type of soil that can be produced from it. Other controls on the formation of soil include soil moisture, temperature and biological organisms.

- Certain minerals such as quartz, are generally tough and resistant to all types of weathering. If a rock contains large quantities of quartz, it will be very resistant to weathering, and its soils will tend to be uniformly sandy regardless of the climatic conditions under which its soils formed. Some light-colored rocks such as basalt and gabbro, weather easily. Their feldspar and pyroxene minerals decompose readily to clay minerals, forming dark-brown, fine grained clayey soils and the iron released in the process is oxidized to brownish minerals. Limestone & dolomite soils are unusual in that they consist mainly insoluble components in the mother rock and they tend to be thoroughly oxidized to terra rosa (intensely red) soils.

➢ **Soil Structure and Color**.

- Soil structure refers to the way in which soil grains are grouped together into larger pieces held together by soil colloids (mixture in which very small particles of one substance are distributed evenly throughout another substance). Soil structure influences the rate at which water is absorbed by soil, the susceptibility of the soil to erosion, and how easy it is for plant growth.

- Color can tell much about how soil is formed and what it is made of. Soil horizons are usually distinguishable by color differences. One sequence of colors ranges from white, through brown, to black as a result of increasing content of humus, which is finely divided, partially decomposed organic matter. The red color is particularly associated with sesquioxide (an oxide in which oxygen is present) of iron, whereas the yellow color may indicate the presence of this same iron compound combined with water (hydrated iron oxide). Greyish and bluish in soils of humid climates often mean the presence of reduced iron compounds in the soil and indicate poor drainage or wetland conditions. Although some recently formed soils retain the color of the parent rock; and fully developed soils is independent of what lies beneath. Color usually varies with the moisture content of the soil.

Soil PH.

- PH is an abbreviation for “power of hydrogen”, where “P” is short for the German word for power, - **“Potenz**” and “H” is the symbol for **Hydrogen.** Hydrogen is the most abundant chemical substance in the universe, constituting roughly 75% of all baryonic mass.

- **What is meant by soil PH?**

  - Soil PH is a measure of the acidity and alkalinity in soils. PH levels range from 0 to 14, with 7 being neutral; below 7 acidic and above 7 alkaline. The optimal PH range for most plants is between 5.5 and 7.0. However, many plants have adapted to thrive at PH values outside this range. Soil PH is very important because it directly affects soil nutrient availability. Plant roots can only absorb nutrients after they have been transformed into certain ionic forms.

  - For example: At low PH, many elements become less available to plants, while others such as iron, aluminum and manganese become toxic to plants. Soil PH is measured on a scale of 0 – 14, with 7 as the neutral mark; and the ideal range for most plants is between 6 – 7.

The following Factors play an important role in Soil formation:

- **Topographic Position –** In high-lying areas the finer soil particles are washed out of the soil by rain water. This water gravitates down to lower lying areas where the finer particles will accumulate. Soluble compounds produced during weathering process will be removed by soil moisture; such soils are said to be leached. One possible consequence is a course, sandy soil with low mineral content in the high lying areas, whereas in the low-lying areas will be fine grained, clayey soil and rich in minerals.

- **Climate –** can be seen as rainfall patterns, evaporation, temperature, humidity, wind etc. - that commonly occur in an area. Rainfall, infiltration of water into the soil and evaporation will determine available moisture. This has an important effect on the type of soil that will prevail.

- **Temperature –** also influences formation of soil. Certain soil-forming processes proceed faster at higher temperatures. Decomposition of organic matter in a composite heap by the bacteria proceeds best when the heap is warm. That is why an actively decomposing compost heap causes steam plumes on a cold morning. The upper zones in the soil profile are normally those most influenced by bacterial action.

Soil Horizons or Soil Catena.

- Soil profiles relate to the changes in the nature of soil sequence from top to bottom. The different layers are called horizons. Soil profiles can typically be divided into the following horizons, not all of which may be present in a given soil.

  - **O** – horizon: this is the organic horizon, and refers to the layer of accumulation organic detritus

on top of the soil.

- **A** – horizon: this horizon lies below the O - horizon, and consists of a mixture of sand and organic matter.
- **B** – horizon: the B – horizon is differentiated from A – horizon by lack of organic matter, which is also evident in color difference between A & B horizons (A – horizon being darker than B).
- **C** – horizon: this layer consists of a mixture of fragmented rock and weathered rock fragments.
- **D** – horizon: the D – horizon is the parent rock and consists of solid rock underlying the soil layers. This is not part of the soil.

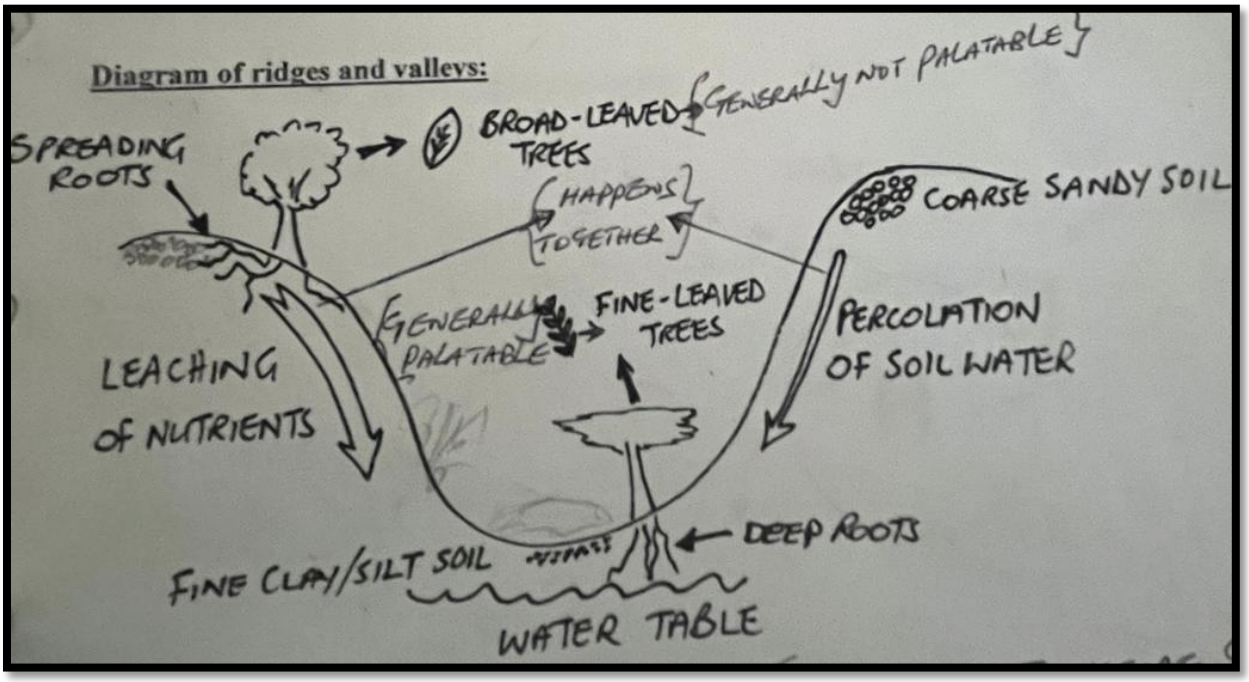
Topography.

- Topography (or the shape of the landscape) is the result of denudation (combined effect of weathering and erosion) of the underlying rock formations, also known as the mother material. The topographic attitude has an effect has an effect on soil-forming processes.

Land form and Landscape.

- The combination of mother material, topography, climate, soils, vegetation and associated animal life forms a landscape. Different rocks have distinct mineral compositions, and they weather at different rates. Each rock type will thus create a unique topography with distinct soil types. The type of soil, in combination with a specific climate, dictates which specific plant communities will develop. This will influence the specific herbivore communities that can be supported, which in turn will determine what meat-eating communities will occur.
- Granite is considered an acid rock because of its specific chemical composition. Such rocks tend to be relatively resistant to weathering and they normally form sandy soils with low PH (acidic). The soil does not contain water efficiently, and leaches easily, which leads to a reduction in mineral content. In high-lying areas with cold winters and wet summers the results are grassveld which will support grazers like Eland and Hartebeest for part of the year. In areas with lower summer rainfall and warmer winters, the product is broad-leaved savanna with tall unpalatable grasses supporting browsers such Giraffe, Kudu, Impala or large bulk roughage feeders like White rhino.
- Basalt, in contrast to granite, is considered a basic rock. Most rocks with a chemical composition in the same class as basalt will tend to weather easily, characteristically producing fine-grained clayey alkaline soils. The soil holds water well and is rich in minerals. In areas with low summer rainfall and mild winters, the result is fine leaved Vachellia (Acacia) type of trees with short, tasty grasses. This is where large herds of grazers such as blue wildebeest, Common zebra and Buffalo can be found.

- **Ridges and Valleys – see diagram below:**



Weathering and Erosion (3.1.5).

- Weathering is the process whereby a rock is decomposed at the surface of the earth under ordinary temperatures and pressures. Weathering can mean breaking the rock up into smaller pieces and/or it can have its mineral components changed chemically into new minerals. Weathering and erosion should not be confused, - weathering takes place on the spot, whereas erosion involves the transport of material to another place.

- Weathering happens to rocks, - it basically occurs in two forms, namely physical or chemical weathering which work together to change parent rock into soil. Fine-grained rocks that cooled quickly will weather at a fast rate because the small grains are easy to break off to create soil. Large-grained rocks that cooled slowly are more difficult to break down by weathering and take a long time to turn to soil.

- **Physical or Mechanical Weathering –** the chemical composition of the minerals in the rock stays the same, only the size of the rock particles changes. The possible causes are:

- Sand or rock bashing against other rocks because of water or wind.
- Water in rocks freezing and expanding to crack the rock, - this can be called **wedge** weathering.
- Temperature cause rocks to expand and contract, and then crack or exfoliate.
- Man and animals break off pieces of rock during daily movements.

- **Chemical Weathering** – Results in changes to the actual chemical composition of the rock as

well as the particle size. Also called **corrosion.** Possible causes are:

- Acidic rain water dissolves rock.
- Plant roots also dissolves acids that affect rock.
- Lichens, algae and bacteria also break down rock with their life systems.

- **Oxygen** and **Water** are the two things that affect the rate of chemical weathering the most, - by forming new compounds when they combine with minerals in the rock that are either soluble in water or that are then easier to weather, or erode by other means.

➢ **<u>Erosion.</u>**

- Erosion happens to soil, - it is a three-phase process where the soil grain is:
- Broken off the soil mass.
- Transported by water or wind.
- Deposited somewhere else.

- Erosion is basically the transportation of weathered material from one place to another. Gravity is the main driving force behind all water and wind erosion. Wind erosion is self-explanatory and basically happens in only one way.

- There are different types of water erosion as follows:

- **Overland Flow –** where the material is dragged over the surface by wind or water flowing over sand. The rate of erosion increases with increasing slope angle, length of the slope (builds up speed) and rate of movement of the force (wind, rain, or flood water). It decreases with these factors as well but also with increased porosity of the soil and resistance of the surface (vegetation).
- **Splash** – from the force of falling rain drops where particles are lifted and deposited elsewhere. On slopes, this increases the overland flow because the drops seal off gaps for infiltration of water.
- **Sheet Erosion** – when overland flow removes soil in uniform layers.
- **Rill Erosion** – describes lots of small, closely-spaced channels that are roughly parallel.
- **Gully (Donga) Erosion** – describes erosion where the rill channels coalesce (to come together) to form big channels, now called gullies.

- **Below is a diagram of Weathering & Erosion:**

