THE INSTITUTE OF EDUCATION

Geography

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Higher Level

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Plate Tectonics and the Global Distribution of Volcanoes

Karst Landforms

Contrasting Regions – Climate and Economic Development

Folding and Faulting

2008 – QUESTION 2 B – VULCANICITY SAMPLE ANSWER

Explain how the study of plate tectonics has helped us understand the global distribution of volcanoes. [30m]

ANSWER

The study of **Plate Tectonics** tells us that the Earth's outer layers are the crust and upper mantle. Together, they form a solid, rock shell around the Earth. This zone is known as the **lithosphere**.

- The lithosphere is broken into many different parts. Each part is known as a **plate**. Each plate is slowly moving. This movement is driven by powerful natural forces from inside the Earth. It is at the **plate boundaries** or **margins** that the impact of plate movement is greatest.

A **volcano** is a mountain that has formed from the eruption of volcanic materials onto the surface. These materials include **lava**, ash and cinders. Volcanoes form at a surface opening of the crust. Over time, the erupted materials will build up to form a cone shaped structure (volcano).

- A volcano will form if **magma** (molten rock) forces its way up through the solid crust. The magma will melt the crustal rocks forming a large **magma chamber**. As the magma moves upwards, gases expand. This propels the magma upwards onto the surface.

There is a clear link between Plate Tectonics and volcanoes. Plate movements create the circumstances that allow volcanoes to occur. Over 80% of volcanoes are found at/near plate boundaries. They will form at Constructive and Destructive plate margins.

CONSTRUCTIVE PLATE BOUNDARIES

This is where two plates are being pushed away from each other. The divergent movement is most likely caused by two heat (convection) currents of magma. Both current rise slowly upwards to the surface. They then move laterally (sideways) in two opposite directions. This drags the plates apart.

- As the overlying crust is pulled apart, the rocks will experience great stress and tension. The rocks will fracture. Magma will then be able to break through and erupt as lava. This forms new crust.
- **Fissure eruptions** occur along this boundary. This is where large amounts of lava flow out from long cracks in the ground surface. These cracks are a few metres wide but extend for kilometres.
- **Basic lava** flows are common. These lavas have a **low silica content**. This allows volcanic gases to easily escape. Eruptions tend to be regular and gentle in nature.
- **Basic lavas have a low viscosity**. This means that they can flow easily. They can travel long distances before cooling. They can also spread out over a wider area.
- **Shield volcanoes** form from these types of eruptions. This is a volcanic mountain cone. It has very gentle slopes but extends over a very wide area.

EXAMPLE – the **Mid-Atlantic Ridge** – this is a great underwater mountain range. It formed from continuous lava eruptions caused by the moving apart of the **North American** and **Eurasian** Plates.

EXAMPLE – **East Africa Rift Valley** formed by the splitting of the African Plate.

DESTRUCTIVE PLATE BOUNDARY

- **This is where two plates move towards and push into each other. The convergence is most likely to be caused by two mantle convection currents moving towards each other. This leads to a collision between the plates.**
  - As the two plates collide, **subduction** occurs. The plate with the heavier crustal rocks is pushed down into the asthenosphere/mantle. It is pushed below the other advancing plate. Subduction will occur at an **oceanic-continental** boundary or an **oceanic-oceanic** boundary. **Only oceanic crust can experience subduction**. Continental crust is not pushed downwards.
  - The subducting oceanic crust is pushed down into much higher temperatures. This leads to the **melting** of the subducting plate. This leads to the formation of large amounts of **magma**.
  - The overlying crust has experienced much stress and pressure. Cracks (faults) and other weaknesses form. These allow the magma to force its way to the surface.
  - **Central vent eruptions** are common at this plate boundary. This is where lava and other volcanic materials erupt at the same location. The magma pushes upwards through a main vent or pipe.
  - **Acidic lava** eruptions are common. These are lavas with a **high silica content** (Over 70%). They trap gases. As the gases cannot easily escape, it leads to violent explosive eruptions.
  - **Acidic lava has a high viscosity**. This means that they flow very slowly. They do not tend to travel far. They cool and harden close to the eruption.
  - **Composite volcanoes** are common at this plate boundary. These are volcanic mountain cones with steep slopes. Examples include Mt. Etna, Mt. Vesuvius, etc.
- EXAMPLE – **Pacific Ring of Fire** – this is a volcanic zone where 70% of active/dormant volcanoes are located. Many plates are in collision with each other, e.g. Nazca Plate (oceanic crust) / South American Plate (continental crust) which causes volcanic activity in the Andes Mountains. **Volcanic island arcs** have formed where oceanic plates collide, e.g. the Phillipines.

HOT SPOTS

- **These are places of intense heat within the mantle. These very high temperatures cause volcanic activity on the surface. There are up to 50 hot spots in the world. Most occur at plate boundaries but some occur far away from plate margins.**
  - It is believed that the intense heat drives currents of magma up towards the surface. These upward rising currents are known as **plumes**.
  - The magma breaks through the crust leading to volcanic eruptions. Over time, a volcanic mountain forms. The overlying plate will move due to tectonics but the hot spot does not move.
  - A series of volcanoes will form over millions of years. A volcano will stop forming once it moves over and past the hot spot location. A new volcano will then begin to form over the hot spot.
- EXAMPLES – **Iceland** is an example of a hot spot formed at a plate boundary. **Hawaii** is an example of a hot spot not formed at a plate boundary.

Stalactite – An Underground Karst Landform

Introduction – Description of Landform

- **A stalactite is an example of an underground feature that is found in a limestone rock or karst areas. It will form in an underground cave (cavern)**.
  - It is a **downward pointing**, **icicle shaped feature** that forms on the **roof of a cave**. It is a build-up of calcite mineral deposits that grow downwards from the cave roof.
  - The icicle-like shape means that a stalactite is wider and thicker at the top where it first forms. It will narrow to a thin tip at its lowest point.
  - (The stalactite is an example of a **speleothem**. These are limestone features that are formed in an underground cave).

Examples

- Examples of the location of caves where stalactites are found include the following;

Irish Examples
▪ Pol an Ionain/Doolin Cave (Co. Clare)
▪ Aillwee Cave (Co. Clare)
▪ Marble Arch (Co. Fermanagh)
▪ Mitchelstown Cave (Co. Tipperary)
▪ Crag Cave (Co. Kerry)

Formation of Stalactites – Limestone Characteristics

- Stalactites will form underground because of the nature of limestone rock. This rock type has characteristics that determine the formation of this landform.
  - **Limestone Strata** – Limestone is made up of many different layers known as **strata**. It is common that the layers lie horizontally on top of each other. They are separated by **bedding planes** which will also run horizontally through the rock.
  - **Permeable Limestone** – Water can pass through the rock because limestone is well-jointed with many vertical cracks called **joints**. Water will be able to seep downwards through these cracks and along the bedding planes, of the limestone layers.
  - **Calcite** – Most of the limestone is made up of a mineral called **calcium carbonate** or **calcite**. This mineral cemented the rock together during lithification. It can account for over 70% of the actual rock. It is also soluble, i.e., it can be dissolved by water.

Formation of a Stalactite – The Process of Carbonation

- The main process in the formation of stalactites is the chemical weathering process of **carbonation**. This is the impact of carbonic acid on the calcite of the limestone. It will be an on-going process in limestone areas that have regular rainfall, e.g. the **Burren**.
  - Rainwater will mix with carbon dioxide (CO_2) to form a weak carbonic acid. More acid will form as water seeps down through soil on the surface. It will move down the joints and along bedding planes of the permeable limestone. They are widened.
  - A chemical reaction will occur between the carbonic acid and the calcite. The calcite will slowly dissolve and is carried away in solution in the water as calcium bicarbonate.

Formation of a Stalactite – The Build-up of Dripstone

- **Water filled with dissolved calcite** moves down through (percolates) the limestone layers and reaches an **air filled underground cave**.
  - Water will drip slowly down from a narrow joint on the cave ceiling. As water comes into contact with air, the chemical reaction that caused calcite to dissolve is reversed.
  - While most of the water drop will fall downwards, some of the water will evaporate as CO_2 escapes back into the air. This ability of each water drop to hold dissolved calcite is reduced. (Not all of the water is evaporated because of the cool cave temperatures).
  - Each drop will deposit a tiny ring of solid calcite at the rim of the drop. Each new drop deposits another calcite ring before falling. Calcite deposits are known as **dripstone**.
  - There is a build-up of calcite at the same point as the overlying narrow joint ensures a supply of water.
- The calcite ring will grow downwards because of **gravity**. The downward growth of the calcite ring forms a **fragile, hollow, thin, narrow tube** called a **straw**. Downward moving water drops add more calcite to the tip of the straw.
  - The stalactite straw tube may become blocked with debris carried in the water. This forces the water drops to flow down on the outside of the straw. Calcite is deposited on the outside and tip of the straw. It becomes wider and longer (icicle-shaped cone).
  - The speed of downward growth of stalactites is very slow and can thousands of years. Rates of growth can be as little as 0.01 mm. Some will grow to great lengths, e.g. The Great Stalactite in the cave at Pol an Ionain is 7 metres long.
  - Stalactites can vary in colour. They can be white if the calcite is pure. Darker colours form if other minerals (e.g. iron) or mud particles are carried in the water.
- Other dripstone landforms develop from stalactites in underground caves. These include
  - **Stalagmites** – build-up of calcite formed from water drops falling from a stalactite.
  - **Limestone Pillar –** formed when a stalactite and stalagmite join together.
  - **Limestone Curtain** – a series of stalactites grow beside each other from a roof crack.

Contrasting Regions – Impact of Climate on Economic Development

Question

- Examine the importance of climate to the economic development of any two contrasting European regions (not in Ireland) that you have studied. **[30 marks]**

Answer

Region 1 – The Paris Basin

The Paris Basin is located in northern France. In economic terms, it is a **core region**, i.e., it the most developed economic region of France. One favourable natural influence on its economic development is climate.

Climate

- The climate of the Paris Basin is a mix of two climate types. Western parts experience a **Cool, Temperate Oceanic** climate. Eastern and southern parts experience a more **Continental** climate. This combined influence leads to much of the region having a **transitional** climate.
  - **Moderate temperatures occur**, i.e., extremes of summer/winter temperatures are rare. Summer temperatures average between 16°C to 20°C from west to east. Winter temperatures range between 5°C to 2° C from west to east.
  - Rainfall levels are also moderate with rare extremes. Rainfall falls throughout the year and ranges between 800 mm to 700 mm from west to east.

Impact on Economic Development

- The most direct impact has been on agriculture. Climate conditions are very favourable and have influenced the development of a successful and productive farm sector.
  - The rainfall and temperature conditions allow for a long growing season. This has led to the development of a wide range of crops and farming activities. They include;
    - **Arable Farming** – Cereal crops such as wheat and barley are intensively produced in areas such as the **Ile de France** and **Beauce** (highest yields in the EU).
    - **Pastoral Farming –** High yields of grass growth have all for the development of dairy farming. This occurs in **Brie** which produces high quality milk, butter and cheese.
    - **Market Gardening –** Climate conditions allow for the growth of a wide range of fruit (apples, strawberries) and vegetables (lettuce, asparagus) in the Ile de France.
- The successful development of agriculture has been an important foundation for the overall expansion of the economy of the Paris Basin. It has provided the basis for a wide range of secondary and tertiary economic activities.

Region 2 – The Mezzogiorno

- The Mezzogiorno refers to Southern Italy (including Sicily and Sardinia). In economic terms, it is a **peripheral region**. This means that it physically isolated and economically less developed than other regions. In 2016, this region accounted for only 23% % of the Italian economy. Climate has had both a negative and positive impact on the region's economic development.

Climate

- The region experiences a **Mediterranean** climate with a hot summer and a mild winter.
  - Summer temperatures are high and average between 25°C – 30°C across the region. There are long periods of direct sunshine. Winter temperatures average around 10 C.
  - Rainfall levels averages around 700mm during the year. Eastern areas receive lower levels (400mm). There are low levels of rainfall in summer. Droughts can occur, e.g. 2016.

Impact on Economic Development

- The most direct influence has been on agriculture and tourism. Agriculture was the region's most important economic activity and its potential was limited by summer conditions. In recent times, reforms have allowed the regions to specialise its farming activities.
  - Low summer rainfall has been **very restrictive** in the growing of cereal crops. **Irrigation** is necessary. This contributed to the poverty of many farmers in the past (low output).
  - Grass growth is also restricted which **limited pastoral farming**. In inland areas, there was an emphasis on goat and sheep herding as they were better able to adapt to the conditions.
  - Climate conditions benefit the growing of **citrus fruits** such as oranges, lemons and limes. They also benefit the growing of drought resistant olives and vines. In recent times, there has been much specialisation of the growing of these crops in coastal areas. Much of this output is supplied across the European Union.
- A positive influence of climate has been the development of the **tourist industry** in the region. The hot summers are an attraction for visitors from the cooler temperatures of Northern Europe. Popular destinations include the island of **Capri**, the **Amalfi Coastline** and **Sicily**.
  - Tourism has many advantages for the Mezzogiorno. It creates direct benefits such as employment, income and revenue. It also benefits supporting industries such as agriculture and transport. This is important to an area that still faces serious economic challenges such as high unemployment.

2007 – Question 3 B Structures of Deformation – Sample Answer

Question

Examine the impact of folding and faulting on the landscape. In your answer refer to one landform in each case. **[30m]**

Answer

Impact of Folding on the Landscape

Folding is the name used to describe the bending of rock layers. The layers will buckle and bend into a series of wave-like curves. This process will occur underground and within the crust. This happens when the rock layers are exposed to great pressures causing rocks to be pushed together.

- Folding will have a great impact on the surface landscape. They will change the shape of the landscape and create new landforms. The main landform that develops is a **fold mountain**.
- Fold mountains are a series of high altitude mountains. Their peaks can reach heights of up to over 3000 metres. They form from the upward pushing of folds over millions of years.

EXAMPLES – The **Alps**, **Himalayas**, **Rockies** and the **Andes** are among the great fold mountain ranges of today's world. Irish examples include the **Wicklow Mountains** and the mountain ranges of the **Munster Ridge and Valley** (Galtee Mts., Comeragh Mts.)

Formation

Folding will mostly impact on **sedimentary rocks**. These are rocks that are formed from the sediments of older rocks pieces and living organisms. The sediments will build up on the floor of a sea or ocean. They form a series of horizontal rock layers. Examples - limestone, sandstone, etc.

- Folding is the result of tectonic plate movements. It occurs when two plates move towards each other. This will cause a collision between both plates, i.e., a **destructive plate boundary**.
- As the plates move towards each other, the rocks of each plate are placed under great pressure. This pressure is called **compression**. The rocks are squeezed and squashed together.
- At lower depths in the crust, rocks are exposed to greater heat and pressure (overlying weight). These rocks are said to be ductile. This means that they do not crack or break because of the force of compression. Instead they will bend into new shapes.
- This **deformation** of rocks is folding. Different types of folds will form depending on the resistance of the rock and the amount of pressure. These include **anticlines** (upward folds) and **synclines** (downward folds). The sides of these folds are known as the **limb**.

At destructive plate margins, the ongoing compression of rocks can occur along much of the plate boundary. This leads to an ongoing upward movement or **uplift** of the crustal rocks.

- **The uplift will push the ground surface upwards to form mountains. This process of mountain building is called orogeny. It will occur over millions of years**.
- This has occurred with the formation of the Andes Mountains. They formed as the Nazca Plate moved below (subduction) the South American plate. This caused folding and uplift of the western edge of the South American plate to form the Andes.

Impact of Faulting on the Landscape

- Faulting is the name used to describe the cracks and breaks that occur in rocks. It is along these rock cracks that rocks will move. Rocks can move upwards, downwards or sideways along a fault.
  - Faults will develop when rocks in the crust come under great stress and pressure. It is most common in rocks near the surface.
- Faulting will impact upon the landscape by forming various landforms. A major example of this is a **rift valley**. This is formed when a surface area of the land slips down between two faults.

  EXAMPLES – **East Africa Rift Valley** (Kenya); **Rhine Rift Valley** (Germany/France).

FORMATION

- Rocks near the surface are more brittle than rocks at deeper levels. This means that they are prone to cracking if they come under stress. This is due to the colder temperatures of rocks near the surface. It is also because of the lower pressure (weight) on crustal rocks close to the surface.
- Plate movements will create stress on crustal rocks. Rift valleys will form at **divergent plate boundaries**. This is when two plates move apart from each other in opposite directions.
  - This plate movement creates an **extensional stress**. It means the rocks are stretched. They become thinner because of this. This makes rocks more brittle ( ).
  - The most common type of fault that occurs because of this stress is called a **normal fault**. This is when one block of rock slips downwards along a fault (under the influence of gravity).
  - This impacts on the surface by causing a downward movement of the ground surface. The exposed upper fault forms a steep slope or cliff called an **escarpment**. It marks a change in land height.
- **A rift valley will form if two normal faults form parallel to each other**. The land in between both faults will slip downwards under the influence of gravity. The land in between the faults is the rift valley. It is at a lower height level. It will be bordered by escarpments on each side (along the exposed fault). A rift valley is also known as a **graben**.

2008 – Question 2 B – Sample Answer

Question

Examine, with reference to an example you have studied, the formation of one rock-type and how it produces a distinctive landscape. [30m]

Answer

Rock type will determine the type of landscape found in an area. It will also influence the landforms that make up the landscape of an area. An example of a rock type is limestone. It can develop into a distinctive landscape known as karst.

Formation of Limestone

- Limestone is a type of **organic sedimentary** rock. It was formed from the **shells and bones of marine creatures**. They fell onto and built-up on the sea bed.
  - **Carboniferous limestone** is common in Ireland. It formed during the Carboniferous period (from between 300–350 million years ago). The land area of Ireland was then located near the equator. A shallow tropical sea covered the sea bed, rich in marine life.
  - Carboniferous limestone forms the bedrock of the centre of Ireland, e.g. **Co. Dublin** to east Galway. It is exposed on the surface in the **Burren** in Co. Clare.
- **Limestone was formed by the process of lithification. This is the gradual change of sediments from loose particles into solid rock**. This process involves two key aspects;
  - **Compaction** – Fresh sediments fall onto the sea-bed as loose material. The sediment is full of small spaces (pores) that are filled with water or air. These sediments are buried under newer sediments. The weight on the deeper sediment particles increases.
    - **Compression** of the deepest sediment particles occurs. They are packed and squeezed closer together by the increasing weight of overlying materials. The pore spaces are reduced. Air and water is pushed out of the smaller pore spaces.
  - **Cementation** – The pore spaces are filled with minerals. They interlock with the sediment particles. The minerals cement the sediment particles together into solid rock.
    - The cementing agent in limestone is **calcite**. It accounts for up to 80% of the actual carboniferous limestone rock. Calcite influences the rock colour, e.g. pale grey.
- **Stratification of limestone occurs during its formation. This means that the rock is made up of a series of layers or strata. Each layer is known as a bed or stratum**.
  - Each layer shows a different period of build-up of marine sediment particles. They reflect the conditions that existed at that time, e.g. climate conditions. Each layer is separated by a **bedding plane**. This marks the boundary that runs between two layers.
  - Layers form horizontally. Older layers are found at deeper levels. The more recently formed / newer layers are found near the surface (form bedrock under soil cover).
- After formation, limestone may become marked by vertical cracks called **joints**. They usually result from the impact of folding and faulting, e.g., bending / cracking layers.

Distinctive Landscape

- Limestone will form a distinctive landscape known as **karst**. This is where the limestone at and below the surface is exposed to the impact of chemical weathering. It is a landscape with little surface drainage, thin soil cover and a range of unique surface and underground landforms.
  - An Irish example of a karst landscape is the **Burren**. It is located in Co. Clare and covers an area of 360 km2.
- There are two key factors that explain why this distinctive landscape develops from limestone rock. (It is more likely to occur if much of the overlying soil cover has been removed. In the Burren, glacial erosion and human activity removed much of the original soil cover),
  - **Permeable Rock** – Water can pass down through the limestone layers. It does so by seeping into the weaknesses in the rock. Rain water can flow downwards from the surface.
    - Rain water will pass down the vertical joints and along the horizontal bedding planes. It is because of this that water seeps deep into the underground layers.
  - **Carbonation** – This is a chemical weathering process. It is the impact of carbonic acid on the mineral calcite. Carbonic acid is formed when rainwater mixes with carbon dioxide (CO2).
    - The acids are carried by rainwater into the joints and bedding planes. A chemical reaction occurs between the calcite and the carbonic acid. The calcite slowly dissolves. This widens the joints and bedding planes. The dissolved calcite flows away in solution in the water.
- The dissolving of calcite will lead to the gradual breakdown of the limestone rock. It leads to the formation of unique landforms on both the ground surface and within the underground layers.
  - **Surface Landforms** – the exposed limestone on the surface is worn away to form;
    - Limestone Pavements – these are large, flat expanses of bare rock. They are divided into a series of clints (slabs) and grikes (cracks) that give a pavement appearance.
    - Swallow holes – funnel shaped depressions into which surface streams flow.
  - **Underground Landforms** – A number of features will form within the limestone layers;
    - Caves/Caverns – large cavity spaces form underground. A cave is likely to be part of an underground network of passages, tunnels and caves through which streams flow.
    - Stalactites/Stalagmites – These are features that form in underground caves. Stalactites are icicle shaped features of calcite that grow downwards from the roof of the cave. Stalagmites are a build up of calcite on the cave floor.
- **Lack of Drainage** – Karst regions have very few surface streams or rivers, even in areas of high rainfall, e.g. the Burren. This is because most rain water will seep downwards from the surface before it can gather in streams. Most surface streams that form will flow into a swallow hole.