Edexcel Geography A-level

Glaciated Landscapes and Change

Essential Notes

Climate Change & Glaciated Landscape Formation

Factors of Climate Change

- Glacial landscapes have a **low level of resilience**; they are sensitive environments and thus vulnerable to **physical and anthropogenic threats** such as climate change.
- Throughout Earth's history, the climate has fluctuated between **greenhouse and icehouse** states. These two climatic states last for millions of years. Within the icehouse stage, glacial and interglacial periods occur which last for less than 1 million years.
- Long term climate change can be described by **Milankovitch Cycles**. Milankovitch's theory of astronomical climate forcing states that global energy alters, forcing global changes due to the variation in the earth's orbit. These changes involve:
    a) **Stretch/Eccentricity**: The earth's orbit changes from circular to eclipse every 96000 years which changes the distance between the earth and the sun.
    b) **Tilt**: The Earth's tilt changes between 21.8 degrees and 24.4 degrees every 41000 years. If the tilt is greater, tropics receive more energy and thus become larger.
    c) **Wobble/Axial Precession**: Every 22000 years, the Earth's seasons change.

Origin: *grahamhancock.com*

- **Short Term** causes of Climate Change involve:
    - **Variations in Solar Output**: Energy output of the sun is not constant. Sunspots occur by magnetic storms, forming dark areas on the sun which increase solar output. The number of sunspots increase/decrease in an 11 year cycle. During the Medieval warming period, there were high numbers of sunspots but during the Maunder Minimum, there were few sunspots.
    - **Volcanic Eruptions**: These can block sunlight, lowering global temperature and triggering mini ice ages. For instance Mount Tambora in Indonesia erupted in 1815 and lowered global temperature by 0.5 degrees Celsius.

The Cryosphere and Periglacial Processes

→ The **Cryosphere** is the term given to frozen water on the earth's surface. This takes into account ice, glaciers, ice caps and glaciers which are vital in stabilising ocean temperature and climate.
→ The diagram below shows the vast difference in ice cover today and during the maximum extent of the ice age.

→ **Periglaciation** describes the geomorphic processes which results from the thawing of snow in areas of permafrost (frozen soils). The runoff of melting snow refreezes into ice wedges and other distinct structures such as **patterned ground, pingos and loess**.
→ Periglacial processes include high winds and meltwater erosion alongside:
- **Nivation**: erosion of the ground around a slope of snow due to freezing and thawing.
- **Frost Heave**: the uplift of soil due to the expansion of groundwater when freezing
- **Freeze thaw**: Water falls through cracks in rocks, freezes, expands and breaks the rock.
- **Weathering**: Wear away from the long exposure to the climate and atmosphere.
- **Solifluction**: the movement of wet soil/material down a slope.


Figure 1: Pingos


Figure 3: Patterned Ground


Figure 2: Loess


Figure 4: Ice Wedges

Glacial Processes

Mass Balance

- Glaciers develop from the compaction of snow and ice. The **zone of accumulation** is where snow is added. As more snow falls, it is compacted into layers so the bottom layers become ice.
- The force of gravity moves ice downhill. Near the snout, the glacier ice may melt. This is called the **zone of ablation**. For equilibrium, the ablation and accumulation zone must be more or less similar for the glacier system to function correctly.
- The difference between accumulation and ablation is called **surface mass balance**. This can be affected by climate change which can alter the rates of accumulation and ablation. It is thus important to consider the **positive and negative feedbacks** of the system.

- A positive mass balance occurs when glaciers gain more mass than they lose. In other words, the rate of accumulation is greater than the rate of ablation. A negative feedback is the reverse of this when melting of the glacier is greater than its formation.
- The **equilibrium line** separates the zones of accumulation and ablation.
- Accumulation can occur from: direct snowfall, **sublimation** (solid turns to gas), avalanches and wind deposition.
- Ablation results from: melting, **calving** (splitting of ice), evaporation and avalanches.

Glacial Movement

- Polar and temperate glaciers have different **rates of movement**.

Movement depends on:

- Amount of precipitation
- Amount of **ablation**
- Steepness of ice
- Thickness of ice
- **Permeability** of the surface which the ice sits on
- Proximity to the equilibrium line.

Other factors controlling rate of movement are:

- Altitude
- Slope
- Size of glacier
- Variations in mass balance,
- Whether the system is positive or negative
- Lithology (characteristic of underlying rocks)

Movement is also dependent on processes such as:

- **Basal Slip**: Glacier sliding over the bed due to meltwater lubricating underneath the ice and increasing movement.
- **Regelation Creep**: Melting and refreezing of ice which affects slippage.
- **Internal Deformation**: When the weight of the ice causes the deformation of ice crystals, usually at the glacier bed where pressure is at its highest.

Glacial Landform System

➔ Glaciers alter landscapes by numerous processes such as:
  - **Erosion**: Wearing away by wind, water and other natural agents.
  - **Transportation**: The movement of debris/ material.
  - **Deposition**: The mixture of unsorted sediments carried by the glacier, often forming moraine landforms.

➔ Glacial landforms develop at **macro** (large) scales, **meso** and **micro** scales. The landforms created are distinctive and occur in both upland and lowland areas. Studying these areas can provide evidence for the extent of ice cover.

Glacial Erosion

Glacial erosion can often produce glaciated landscapes through the following processes:

- **Abrasion:** This occurs when rocks become embedded in the glacier and rub against the bedrock whilst the glacier moves. This causes the wearing away of the landscape, producing a smooth surface. The scratches on the surface which result are called striations.
- **Quarrying:** This occurs within valley glaciers where pieces of bedrock are transported and eroded.
- **Plucking:** Same as quarrying. This process occurs when rocks become frozen to the glacier and are plucked from the ground as the glacier moves forwards. This leaves a jagged landscape behind.
- **Crushing:** The crushing and scraping of a glacier, as it moves, causes erosion along the soil and rock it sits on. The weight of the glacier may cause physical stress to the ground whilst often plucking up boulders which are then deposited downstream.
- **Basal Melting:** The melting point of water decreases under pressure; thus water melts at a lower temperature under thicker glaciers. This can then lead to basal sliding, where a glacier 'floats' above a layer of meltwater (which acts as a lubricant). Thus, the glacier is able to move faster.
- **Subaerial freeze thaw:** Water gets into the cracks of rocks, freezes and then expands by around 10%. This repeated action puts pressure on a rock, eventually causing it to shatter.
- **Mass Movement:** This can happen quickly and thus be a danger. Mass movement refers to the sudden movement of large masses of material (e.g. soil). Usually this happens at a quick rate due to basal slipping.

Glacial Deposition

- Deposition involves the process in which sediment, soil and rocks are deposited (dropped) in an area, creating or adding to landforms.

Glacial depositional landforms include:

- Moraines:
    - **Medial:** Formed from two lateral moraines meeting in the middle of a glacier and depositing material.
    - **Lateral:** Material deposited on the sides of a glacier, leaving a ridge when the ice melts.
    - **Recessional:** Forms at the end of a glacier when a retreating glacier stays stationary for a sufficient time.
    - **Terminal:** Material deposited at the snout of a glacier on the valley floor.
- **Drumlins:** Elongated hills of glacial deposition. Made of material accumulated under glacier.
- **Till Plains** (lowland feature): Till (clay) becoming deposited when ice sheets detach from glacial body.
- **Ablation Till** (lowland feature): Accumulation of till by the melting of stagnant ice.
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Glacial Meltwater

- Water movement within a glacial system can be in the forms of supraglacial, englacial and subglacial flows. **Glacial and Fluvioglacial** (meltwater erosion/deposition) have different characteristics and form specifically.

Glacial Landforms

- Glacial landforms include:
    - **Cirques/Corries:** Deep rounded hollows which capture snow. Plucking/Erosion steepen the back wall.
    - **Arêtes:** A knife edged ridge formed from erosion of two corrie back walls.
    - **Pyramid Peaks:** Forms from erosion between three or more corries, producing a peak rather than a ridge.
    - **Glacial Troughs:** Erosion grinds a v-shaped valley to produce a u-shaped valley.
    - **Truncated Spurs:** Formed when glacier cuts,and erodes through interlocking spurs (number of ridges).
    - **Hanging Valleys:** Main valley erodes quicker than tributary valley, leaving it at a higher/hanging platform.
    - **Ribbon Lakes:** An area of soft rock is eroded more readily than surrounding hard rock on a valley floor. Plucking and abrasion create hollows that fill with ice/rainwater.

- **Ice Sheet scouring** produces the following landscapes:
    - **Roches Moutonnées**: Small rocks are not always removed and become polished by abrasion.
    - **Knock and Lochan:** A scoured lowland which displays alternating roches mountonées and small lakes.
    - **Crag and Tail**: A tapered ridge of glacial deposits extended to one side.

The Use & Management of Glaciated Landscapes

Value of Glaciated Landscapes

- These landscapes have **significant environmental and cultural value**. For instance they provide **scientific research**, **tourist** locations, wilderness and **biodiversity**, recreation as well as having **spiritual and religious** importance. The Himalayan glaciers, for example, is of great value to local Buddhists and religious groups due to its sublime power.
- Despite value, attitudes towards these ranges vary. Whereas some acknowledge the cultural and environmental values and supporting preservation, others **exploit** these areas for economic gain.
- Economically, glaciated landscapes provide **farming and mining** opportunities, **hydroelectric power**, tourism and **forestry**. This - in turn - provides job opportunities.
- The Chamonix Valley in eastern France is visited by 5 million tourists per year. The tourist industry creates 2500 jobs seasonally whilst railway companies and ski-lift engineers are in high demand.
- Glaciated landscapes also have a unique biodiversity (tundra: no trees, permanently frozen soils) and sustain natural systems through the water and carbon cycles. Species living in glaciated landscapes are endemic to that region, they are specially adapted to the conditions there.

Threats to Glaciated Landscapes

- Glaciated landscapes are incredibly **sensitive** environments. This means that any changes could be hazardous to the wellbeing of the system.
- Current threats are both natural and human induced. Natural hazards involve **glacial floods** and **avalanches**, which can be worsened by human activities such as tourism. Tourists can trigger avalanches on ski slopes which can cause injuries and deaths. For instance, the 1999 avalanche in the Chamonix valley killed 12 tourists.
- Perhaps the greatest threat is **climate change** which is interfering with the mass balance of glaciers, speeding up melting and thus increasing flood risks. Melting also releases freshwater which can become polluted. Climate change in these areas thus has the potential to **disrupt the hydrological cycle** by producing greater river discharge, meltwater and poor water quality.

- Human activities which pose threats include **tourism**, **reservoir construction** (which destroys the natural pristine environment) and **urbanisation**, which stresses the environment and increases the population exposed to natural glacial hazards.
- Human activity **degrades the fragile ecology** and can destroy the wellbeing of local species. Additionally, soil erosion, trampling, landslides and deforestation reduces the quality of the environment. Usually this results from the direct actions of players, such as tourist companies, who exploit the natural landscape. **Deforestation**, for example, works to reduce resilience as interception is reduced, meaning that an avalanche or flood is more likely to reach the populated reserve.

Managing Threats

- For effective management, a **variety of stakeholders** are often involved to create policies favouring everyone's needs.
- Techniques can involve **agreements**. For instance there is a global policy to preserve Antarctica so it's not used for any other purpose but scientific research. **Legislative frameworks** are used to protect these landscapes by conservation and management but this can create conflict. If total conservation is employed, companies and tourism workers may be affected (jobs lost, facilities banned, livelihoods lost etc.)
- Climate change is a context risk which is extremely difficult to control. To manage this effectively, all scales and players will need to be involved in a way all interests are served as best as they can. The future is **uncertain** under a 'business as usual' outlook but radical approaches are likely to be unwelcomed by the masses.