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GG101 Final Review

Chapter 8: Weather

Weather: is the short-term, day-to-day condition of the atmosphere, contrasted with climate, which is the long-term average of weather conditions and extremes in a region

Air Mass: masses of different temperature and density air that produce weather patterns.
- Characteristics of source regions
  - Moisture- m for maritime (wet) and c for continental (dry)
  - Temperature (latitude factor)- designated A (arctic), P (polar), T (tropical), E (equatorial) and AA (Antarctic)
- cA originate in Siberia and Northern Canada
- cP form only in the northern hemisphere
- mP exist over Northern Oceans
- mT exist near equator. mT Gulf/Atlantic and mT Pacific influence North America weather patterns.

Atmospheric lifting Mechanisms
- Convergent Lifting: air flows toward an area of low pressure
- Convectional lifting: stimulated by local surface heating
- Orographic lifting: air is forced over a barrier such as a mountain range
- Frontal lifting: along the leading edges of contrasting air masses. Ie. Warm air mass pushed up above the cold air mass moving in.

Midlatitude Cyclonic systems: conflict between contrasting air masses
- low pressure center with converging, ascending air spirals inward counterclockwise in the Northern Hem and clockwise in Southern
- Life Cycle of Midlatitude Cyclone:
  - Cyclogenesis: low pressure wave cyclones develop and strengthen, usually begins along polar front, where cold and warm air masses converge.
  - Open stage: eat of low pressure center, warm air begins to move northward, while cold air advances southward to the west of the centre.
  - Occluded Stage: faster moving and denser cold front overtakes the warm front, wedging beneath it. Precipitation can be moderate to heavy and tapers when wedge is lifted higher by advancing cold air.
  - Dissolving Stage: lifting mechanism is completely cutoff from the warm air mass that was its source of energy
- Storm Tracks: pathways that air masses follow across a continent. Shift in latitude with changes in the sun's declination and the seasons.

Violent Weather
Ice storms: freezing rain, ice glaze, and ice pellets, and snow blizzards. Freezing precipitation occurs when super cooled moisture freezes on contact with a surface.

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Thunderstorms: large amounts of energy liberated by the condensation of large quantities of water vapor. Process heats surrounding air causing violent updrafts and downdrafts. Frictional drag of raindrops pulls air toward the ground.

- Lightning: flashes of light caused by enormous electrical discharges.
  - Buildup of electrical energy polarity between areas with cumulonimbus cloud or between the cloud and ground
- Thunder: violent expansion and heating of air creates shockwaves through the atmosphere.
- Hail: ice pellets formed within cumulonimbus cloud. Raindrops circulate above and below freezing and build up until the cloud cannot support their weight.

Damaging Winds

- Linear winds associated with the thunderstorms and bands of showers cause significant damage and crop losses. Straight-line winds, downburst, microbursts, microbursts, or plough winds
- Derechos: term for straight-line winds used un the US, and elsewhere, describes this type of damaging wind event specifically linked to large, organized, fast-moving areas of thunderstorms

Tornadoes: spinning, cyclonic, rising column of midtroposphere level air forms a mesocyclone. Swirl of mesocyclone itself is visible as a funnel cloud, that pulse fomr the bottom of the parent cloud. When it touches Earth it becomes a tornado

- Canada is second to US in tornadoes, with 80 per year.

Tropical Cyclones: powerful manifestation of the Earth-atmosphere energy budget. Originates in tropical air masses.

- essentially homogeneous with no fronts or conflicting air masses
- convert heat energy from ocean into mechanical energy for winds.

Typhoon: tropical cyclone in excess of 74m/h2 that occurs in the western Pacific
Hurricane: tropical cyclone that has fully organized and intensified in inward-spiraling rain bands. Winds in excess of 119km/h-1. Found in Atlantic and Eastern Pacific.

Profile of Hurricane
Classified by Saffir-Simpson Hurricane Damage potential scale

- 5 categories of strength, 1 being weak and 5 being strong
- based off of wind speed of the hurricane

Hurricane Juan

- category 2 storm, started as tropical depression SE of Bermuda
- within 6 hours it increase to a tropical storm
- 18 hours later it was classified to hurricane strength
- Hit East coast of Canada was lightly hit , PEI & Nova Scotia

Chapter 9: Water Resources

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Hydrologic cycle: involves the circulation and transformation of water throughout the Earth's atmosphere, hydrosphere, lithosphere, and biosphere.

- 86% of all evaporation from the ocean 14% evaporates from land
- 78% precip falls on ocean, 22% falls on land

Interception: occurs when precipitation strokes vegetation or other ground cover
Infiltration: water soaks into the subsurface
Percolation: permeates soil or rock through the downward movement.

Chapter 10: Climate Systems and Climate Change

Earth's climate System and its Classification

- Climate is weather over time, can think of it as 'average weather'
- Described using Normals – 30 year averages for weather statistics
- Climatology is the study of climate
- Climatic regions are areas with similar weather statistics

Classification of Climatic Regions

- Genetic classification
- Based on knowledge of causes of climate
- Empirical classification
- Based on grouping areas with similar climate data

Climate components

- Several parameters used to describe climate
- Include the following
- Insolation – measures radiation
- Temperature – measures sensible heat
- Pressure – High or Low, used to predict weather
- Air Masses – indicate temperature and humidity characteristics expected, boundaries result in frontal activity
- Precipitation - type and quantity

Climatic relationships

- Temperature and precipitation schematic
  - Different levels of temperature and precipitation create a different climate
  - Ie. Wet and hot include tropics and subtropics, while Wet and cold include polar ice sheet and tundra.

Climatic Classification

- Tropical Climates – 36% of Earth (land and sea) tropical latitudes
  - Rainforest
  - monsoon
  - savanna
- Mesothermal Climates – 27% (land and sea), seasons (midlatitudes)

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    - Humid subtropical
    - Marine west coast
    - Mediterranean
- Microthermal Climates – 21% (land not sea), pronounced winters (mid to high latitudes)
    - Humid continental
    - Subarctic
- Polar Climates – no true summer (land and sea) (high latitudes and polar regions)
    - Tundra
    - Ice caps and ice sheets
    - Polar marine
- Dry Climates – 35% (land not sea), sparse vegetation, water demands greater than precipitation; arid, semi-arid
- Highland – small in area, high in elevation, cold temperatures

Global Climate Change

Reasons for concern

- Risks to unique and threatened Systems
    - Include irrreversable losses to physical systems, coral reefs, lakes, barrier island, etc
- Risks of extreme Weather events
    - Increase in event magnitude and frequency
- Uneven Distribution of Climate Change Impacts
    - Impacts are greatest in low latitude, less-developed countries
    - Disparity occurs amoung economic classes; range and seasonality of disease vectors
- Aggregate Impacts and Damages
    - Effect combined to assess total monetary damage and lives changed/lost
    - Few developing countries have financial, technical, or intstitutional bas to support adaptation
- Risks of large Scale Discontinuities and Distruptions
    - System responses occur at thresholds where systems fluctuate above and below an average.
    - As conditions change the system cannot maintain operational level and finds new equilibrium.

Greenhouse Gases

- Carbon dioxide and water vapour are the principle radiativley active gases causing Earth's greenhouse effect
    - Radiatively active gases include CO2, methane (CH4) Nitrous Oxide (N2O) chloroflourocarbons (CFCs).
- Computer models accurately track observed temp change when they factor in human-forced influences on climate.

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- Increase of Methane from livestock and burning of vegetation also adds to atmospheric gases.
    - Methane makes up 19% of atmosphere

Climate Models and Future Temperatures

- Temperature, precip, air pressure, relative humidity, wind, and sunlight intensity are sampled in myriad grid boxes.
- Interactions within a grid layer, and between layers on all six sides are modeled in a general circulation model program.

Observed Changes in their Causes

- - IPCC 2014 Synthesis Report is now available at http://www.ipcc.ch/news_and_events/docs/ar5/ar5_syr_headlines_en.pdf
- "Human influence on the climate system is clear, and recent anthropogenic emissions of greenhouse gases are the highest in history. Recent climate changes have had widespread impacts on human and natural systems.
- Warming of the climate system is unequivocal, and since the 1950s, many of the observed changes are unprecedented over decades to millennia. The atmosphere and ocean have warmed, the amounts of snow and ice have diminished, and sea level has risen.

Causes of climate change

- "Anthropogenic greenhouse gas emissions have increased since the pre-industrial era, driven largely by economic and population growth, and are now higher than ever.
- This has led to atmospheric concentrations of carbon dioxide, methane and nitrous oxide that are unprecedented in at least the last 800,000 years.
- Their effects, together with those of other anthropogenic drivers, have been detected throughout the climate system and are extremely likely to have been the dominant cause of the observed warming since the mid-20th century.

Future Climate changes, Risks and impacts

- "Continued emission of greenhouse gases will cause further warming and long-lasting changes in all components of the climate system, increasing the likelihood of severe, pervasive and irreversible impacts for people and ecosystems.
- Limiting climate change would require substantial and sustained reductions in greenhouse gas emissions which, together with adaptation, can limit climate change risks.

Chapter 11: The Dynamic Planet

Geological Time Scale: summary timeline since earth was formed.

- Uniformitarianism – the present is the key to the past.
- Processes that happen slowly now happened slowly in the past; processes acting today are the same as those that acted in the past to produce landscapes that we see today.
- Precambrian Eon accounts for 88.3% of time scale

Earth's Core and Magnetism (2900km-6370km)

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- 1/3 of mass but 1/6 of volume lies in its dense core.
- Differentiated into two regions- inner and outer core
    - Inner core is thought to be solid iron that is well above melting temperature but stays solid from pressure
    - Outer core is fluid and generates 90% of Earth's magnetic field.

Earth's Mantle (250km-2900km)

- lower and upper mantle represent 80% of earth's volume
- rich in oxides of iron and magnesium and silicates
    - dense and tightly packed at depth
- lower mantle is denser and contains a mixture of iron, magnesium, and silicates
- upper mantle consists of 3 parts
    - Upper Mantle
    - Asthenosphere (70km-250km): plastic layer; contains pockets of increased heat from radioactive decay and is susceptible to slow convective currents in the hotter, less dense materials.
    - Lithosphere: high-velocity zone just below crust where seismic waves transmit through a rigid, cooler layer.

Earth's Lithosphere and crust (70 km deep)

- Lithosphere includes crust and upper most mantle, to about 70 km in depth
- Mohorovicic discontinuity (Moho): Internal boundary between crust and high-velocity portion of upper most mantle is another discontinuity.
- Continental crust is essentially granite; it is crystalline and high in silica, aluminum, potassium, calcium, and sodium.
- Oceanic crust is Basalt; granular and high in silica, magnesium, and iron

The Geologic Cycle

Relation between the hydrologic cycle, rock cycle, and tectonic cycle

- fueled by Earth's internal heat and solar energy from space

Rock cycle

- Mineral is an inorganic or non-living natural compound having specific chemical formula and possesses a crystalline structure
- Igneous rocks: solidify and crystallizes from a molten state. Comprise 90% of earth's crust
    - Pluton: intrusive igneous rock that invaded layers of crustal rocks
    - Felsic igneous rocks are high in silica, aluminum, potassium, and sodium. Lighter and less dense
    - Malic igneous rocks- low in silica, high magnesium and iron, have high melting points. Darker and more dense.

- Sedimentary rocks: involves lithification processes of cementation, compaction, and hardening of sediments
    - Sandstone, limestone, and shale are examples
    - Clastic sediments: weathered fragmented rocks that are further worn in transport.

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- Metamorphic: either ignesou or sedimentary rocks can be formed into metamorphic by going through intense pressure and heat.

Rock Cycle:

1. Magma is released from crust, cools and forms igneous rocks
2. Weathering and erosion creates sediments
3. Compaction, cementation creates sedimentary rock
4. Heat intense pressure forms Metamorphic rocks
5. Metamorphic rocks melt and return to the mantle

Divergent plate boundaries: characteristic of sea floor spreading centres, where upwelling material from the mantle forms new seafloor.
Convergent plate boundaries: characteristic of collision zones, where areas of continental and oceanic lithospheres collide. Subduction zones
Transform boundaries: occur where plates slide laterally past one another at right angles to sea-floor spreading centre. No volcanic activity, neither diverging nor converging.

Chapter 13 Weathering, Karst Landscapes, and Mass movement

Geomorphology: Science of landofrms. Study of origin, evolution, form and spatial distribution

Denudation: any process that wears away landforms or rearranges landform materials
-includes weathering, mass movement, erosion, transportation, and deposition.

Differential weathering: effect of different resistances in rock, coupled with the variations in intensity of physical and chemical weathering.

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Dynamic equilibrium model: balancing act between tectonic uplift and reduction by weathering and erosion.

Endogenic events: build initial landscapes, faulting or lava flow
Exogenic events: develop sequential events, rainfall or forest fire.

Geomorphic threshold: point at which energy overcomes resistance against movement.

Equillibrium pattern:
1 equ'm stability in which system fluctuates around some average
2. destabilizing event
3. period of adjustment
4. development of a new and differnet condition of equilibrium stability

slow continuous events, such as soil development and erosion, tend to maintain approx. equ'm condition
dramatic events, landslides, have longer recovery time before equ'm is recovered.

Slopes: inclined surfaces, often with straight or curved segments, that connect flatter parts of the landscape.

Waxing slope: convex surface curves downward and grades in to the free face
Free face: outcrop of resistance rock that form a steep scarp or cliff
Debris slope: downslope of free face, receives rock fragments and material from above.
Waning slope: concave surface along the base of the slope that forms a pediment.

Slopes are open systems and seek angle of equilibrium
Stable if strength exceeds denudation processes
Unstable if material are weaker than processes
Weathering: processes by which surface and subsurface rocks disintegrates, or dissolve, or are broken down. Rocks at or near the Earth's surface are exposed to physical and chemical weathering processes.

Regolith: broken rock created by upper surface of bedrock that undergoes continuous weathering.
Bedrock: parent rock from which weathered regolith and soil develop.

Factors influenceing Weathering Processes

- Rock composition and structure (jointing)
  - Hard or soft, soluble or insoluble, broken or unbroken
  - Joints: fractures in rock that occur without displacement of the sides
    - Increases surface area exposed to weathering
- Climate
  - Precipitation, temperature, freeze-thaw cycles
  - Most important factors of weathering
- Subsurface water

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  - Position of water table
  - Water movement within the soil and rock
- Slope orientation
  - Geographic orientation determines exposure to sunlight, wind, precipitation
- Vegetation
  - Produces organic acids from partial decay or organic matter; contribute to chemical weathering
  - Roots can enter crevices in rock and break it apart.

Physical Weathering: Rock is broken and disintegrated without any chemical alteration
- Produces more surface area for chemical weathering

Frost action (freeze-thaw)
- water is found in small openings freezes and can expand to 9% of the original volume. Pressure is exerted and exceeds the tensional strength of the rock.
-Joint block separation, along existing joints and fractures. Creates frost wedging where rock is made into varied shapes depending on structure. (blocks)

Salt-crystal growth (crystallization)
-occurs especially in arid climates
- dry weather draws moisture to surface, as moisture evaporates, dissolved minerals grow as crystals and can eventually grow to split the rock.

Pressure Release Jointing
- layer after layer of thin rock peels off in curved slabs or plates that slip off in process of sheeting.
- Can feature arch- shaped and dome-shaped features called exfoliation dome

Chemical Weathering Processes:
- refers to the chemical breakdown of the constituent minerals in rock, always in the presence of water.
-all rock forming materials are responsive to water to some degree.

Hydration and Hydrolysis
-Hydration: combination of water. Provides little chemical change, but the water does become a part of chemical composition and stresses rock, forcing grains apart.
-Hydrolysis: decomposition process that breaks down the silicate minerals in rocks.
Creates a chemical reaction within the rock.

Oxidation: when certain metallic elemnts combine with oxygen to form oxides.
-most common form is rusting or iron ore in rocks

Dissolution of Carbonates
Carbonation: reaction whereby carbon combines with and dissolves minerals

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-water vapour readily dissolves carbon dioxide, creating acid rain

Karst Topography and Landscapes
-named for the Krš Plateau in Slovenia, where karst processes were first studied.

Formation of Karst
-Limestone formation must contain 80% or more calcium carbonate for dissolution processes to proceed effectively
-Complex patterns of joints in the otherwise impermeable limestone are needed for water to form routes to subsurface and the water table
-Aerated zone must exist between the ground surface and the water table.
- For more rapid dissolution, vegetation cover is required to supply varying amounts of organic acids that enhance the solution process.

Sinkhole Landscapes
Sinkhole: weathering of limestone landscape, forming cicular depressions in an underground cavern.
-may collapse into cavern leaving exposed sinkhole.
-in wet tropics, karst topography forms deeply jointed, thick limestone beds. The weathering leaves standing limestone blocks (limestone knobs in Puerto Rico)

Caves and Caverns: form in limestone because it is dissolved so easily
-generally form just beneath the water table
- Dripstones: form as water containing dissolved material drips from ceiling
-Stalactites grow from ceiling stalagmites form on floor
-sometimes 2 grow together, eventually touch and create a column

Mass-Movement Processes

Mass-movement: applies to and unit movement of a body of material, propelled and controlled by gravity, such as lahars (fast, high viscosity lava flows)
-can be on surface or can be submarine landslides.
-often used interchangeably with mass-wasting (general process involved in mass movements and erosion of landscape)

Angle of repose: steepness of resulting slope depends on size and texture of grains.
Driving force: force pulling the hill down, gravity
Resisting force: shearing strength of the slope. Vegetation, composition, moisture, etc.

Classes of Mass Movements

Falls & Avalanches
Rockfall: a volume of rock that falls through the air and hits a surface. Individual rocks falls independently and characteristically for a cone-shaped pile of irregular broken rocks in a talus slope

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Debris Avalanche: mass of falling and tumbling rock, debris, and soil. High velocity of materials than slower debris slide.

Landslides: sudden rapid movement of a cohesive mass of regolith or bedrock that is not saturated with moisture.

-large amount of material failing simultaneously
-Rotational slides: surface material moves along concave surface
-underlying clay is impervious to percolating water

Flows: moisture content of moving material is high, the suffix –flow is used.

- mudflow and earthflows are fluid movement of material

Creep: gradual mass movement of surface soil.

- individual soil particles are lifted and distributed by the expansion of the soil moisture as it freezes.
- Solifluction: abundant soil water available during spring snowmelt and causes soil to liquiefy and flow downslope
- Gelifuction: soil flow in periglacial environment. Solifuction formed under permafrost or frozen grounds.

Human-induced mass movements
Scarification: human-induced mass movements of Earth material, such as large-scale open pit mining and strip mining.

Chapter 14: River systems and Landforms

Basic Fluvial Concepts
Erosion: water dislodges, dissolves, or removes surface materials
Transport: solids are moved through the water by flow of the stream
Deposition: materials are laid down in an area different from source.
Alluvium: mixture of clay, silt, sand, gravel and mineral fragments deposited by running water.

Landscapes are produces by two basic processes:

1. Erosion
2. Deposition

Ridges determine the flow of drainage
Precipitation can be collected in multiple streams that run very long and feed into bigger rivers.

Drainage Patterns
Dendritic drainage: treelike pattern, similar to capillaries in human circulatory system or veins in a leaf. Efficient bc overall length of branches is minimized.

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Trellis drainage: dipping or folded topography, exists in places like ridge and valley province, where mountain folds run nearly parallel.
Radial drainage: results when stream flows off of a central peak or dome
Parallel drainage: associated with steep slopes
Rectangular drainage: formed in faulted and jointed landscapes
Annular: produced by structural domes, w/ concentric patterns of rock strata guiding stream courses.
Deranged: no pattern to the stream, may have disrupted surface patterns.

Fluvial Processes and Landforms

Stream Discharge: stream's volume of flow per unit time. Dependant on stream channel width and depth and velocity of flow

Exotic stream: high potential for evapotranspiration rates in the arid regions may cause discharge to decrease with distance along the river. Ex. The Nile

Meandering stream: sinuous(snakelike) form of stream that develops where the slope is gradual

- Undercut bank: steep bank, outer portion of river is subject to greater velocity and therefor greatest erosive action.
- Point bar deposit: inner portion of meander experiences slowest velocity and receives sediment fill.
- Oxbow lake: when a former meander becomes isolated from the rest of the river
    - May fill with organic debris and silt or may become a part of river again if it floods.

Stream Gradient: drop in elevation of a stream from the headwaters to its mouth. Ideally forming a concave slope.
-Graded stream: when channels adjust their slope, size, and shape so that a stream has just enough energy to transport its sediment load.
- Upstream: steeper gradient, means narrower stream with higher velocity. Upper alpine
- Downstream: lower gradient, slower flow, wider stream, mouth of the stream, sediments deposited.

Nickpoints: the point at which the longitudinal profile of a stream is abruptly broken by change in gradient. Ie waterfalls, rapids, cascades

- conversion of potential energy in the water at the lip of the falls to concentrated kinetic energy at the base.
- Eventually works to eliminate nickpoint feature and smooth gradient through erosion.

Floodplain: Flat, lowlying area flanking many stream channels that is subjected to the recurrent flooding. Alluvial deposits usually mask underlying rock.
-contain many landforms associated with fluvial transport and deposition.

- Alluvial terrace: uplifting of landscape and lowering of baslevel, stream cuts downward entrenching itself deeper into the flood plain.

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Delta: the depositional plain formed where the mouth of a river enters a lake or ocean.
-named after the triangular shape of the Greek letter Delta

Ganges delta
- features extensive lower delta plain formed to higih tidal ranges in an arcuate (arc-shaped) pattern.
- Covered by intricate maze of distributaries
- Bountiful alluvium carried from upstream slopes. Provided sediment that is deposited to create deltaic islands.
- Largest in world at 60,000 km2

Nile River delta
- arcuate delta
- extensive agricultural activity in the area

Mississipi River Delta
- 7 different deltas in 5000 years
- receives consistent sediment supply, controlled by levees
- Shrinking of the delta and rising sea level have diminished overall surface area of delta

Rating floodplain risk
Flood: is high water flow that overlfows the natural bank along any portion of a stream.
10-year flood: smaller in size but will happen once every 10 years. 10% chance of it happening any one of those years
50 & 100- year floods: catastrophic floods, not very likely to happen. May happen once every 50 or 100 years, 1-2% chance of happening any year.
Floodplains are labeled according to their flood risk of 10, 50, or 100 year flood.

Stream discharge measurement
3 measurements at a streams cross-section are needed to calculate discharge:
1. Width
2. Depth
3. Velocity, measured with a movable current meter.

Hydrograph: a graph of stream discharge over time for a specific place.

Chapter 17: Glacial and Periglacial Processes and Landforms

Rivers of Ice
Glacier: large mass of ice resting on land or floating as an ice shelf in the sea adjacent to land. Forms by the continual accumulation of snow that recrystallizes under its own weight into an ice mass.
- not frozen lakes or underwater ice

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Alpine Glaciers (Mountain Glacier): glacier found in a mountain range

- comes from the Alps in Europe
- ex Blackcomb glacier
- Valley glacier, river of ice confined within a valley. Flows slowly downhill, land beneath it is dramatically altered by erosion.
- Cirque: bowl-shaped recess where the alpine glacier originated. Cirque Glacier formed
- Piedmont glacier is formed and spreads freely over the lowlands
- Tidal glacier: ends in the sea calving to form floating pieces of ice called icebergs.

Continental Glaciers: larger scale than alpine, continuous mass of ice. Covering at least 50,000 km2

- most of Earth's glacial ice exists in ice sheets.
- Most glacial ice found as ice sheets is found in Antarctica and Greenland
- ice field: not extensive enough to form characteristic dome of ice cap; instead extends in an elongated pattern in a mountainous region.
- Outlet glaciers: flow out from an ice sheet or ice cap but constrained by a mountain valley or pass.
- Ice cap: a large dome-shaped glacier, less extensive than and ice sheet, that buries mountain peaks and local landscape
- Ice field: least extensive form, with mountain ridges and peaks visible through ice. Smaller than ice cap and sheet

Glacial Processes

Formation of glacial ice

- Glacial Ice: a hardened form of ice, very dense in comparison to normal snow; ice that remains for two year or more
- Firn: snow of a granular texture that is transitional in the slow transformation from snow to glacial ice, has persisted through one summer season in the zone of accumulation.
- Analogous to metamorphic processes:
    - Sediments (snow and firn) pressured and recrystallized into a dense metamorphic rock (glacial ice)

Glacial Mass balance

- open system with inputs of snow and outputs of ice, meltwater, and water vapour
- Accumulation zone: moisture builds up to feed the glacier's upper reaches
- Firn line: end of accumulation zone, where winter snow and ice survived summer melting season
- Peyto Glacier in Alberta has experience significant loss in mass since 1966. Indicating negative mass balance, not enough snow to make up for the loss in the summer.

Glacial Movement

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- surface of glacier is fairly brittle
- ice cracks and moves like plastic along the uneven ground. Melting and refreezing as it goes
    - it melts by compression at one point, is able to slowly move and refreezes later.
- Crevasses and breaks in the ice indicate the movement of a glacier
    - Form by friction caused by valley walls, tension from stretching as it passes over a convex slope or compression over a concave slope
- Glacial surge: glacier that may lurch forward with little to no warning
- Glacial Erosion:: passing glacier plucks rock material and carries it away.
    - Abrasion and gouging produces a smooth surface on exposed rock as well

Glacial Landforms

Erosional Landforms created by Alpine Glaciation

Arêtes (knife-edge in French): eroded cirqu walls that form sharp ridges in glaciated mountains.

Col: saddle like depression cirque eroded further than an arête

Horn (pyramidal peak): results when several cirque glaciers gouge and individual mountain summit from all sides

Bergschrund: formed when a crevasse or wide crack opens along the headwall of a glacier, most visible in summer

V-shaped: preglacial valley, before the erosion and pressure of glacier alters landscape

U-shaped valley: glaciated valley, dramatically changed from v to u shape because of glacier processes.

Tarns: small mountain lakes that form in cirques

Paternoster (our father) lakes: small circular-stair stepped lakes. Named after their resemblance to the rosary beads.
-formed by differing resistance of rock to glacial processes or from damming by glacial deposits.

Glacial erratics: rocks transported and left behind by retreating ice.

Hanging valleys: glacier eroded the valley so deeply that there are high steep walls above the valley floor, some of which have spectacular waterfalls.

Fjord: deep valley created by glacier that creates a trough and extends the sea inland. Filling lower reaches of the steep-sided valley

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Depositional Landofrms created by Alpine Glaciation

Glacial Drift: general term for all glacial deposits both sorted and unsorted

- Till direct ice deposits left as unstratified and unsorted debris.
- Stratified drift: sediments deposited by glacial meltwater are sorted by size

Moraines: deposition of glacial sediments produces a specific landform

- lateral moraine: forms along side of a glacier
- medial moraine: two glaciers with lateral moraines join
- terminal moraine: eroded debris is dropped at the glaciers furthest extent.

Valley Train Deposit: melt-water deposited material down valley from a glacier. Ex. Peyto glacier, Alberta

Erosional and Depositional Features of Continental Glaciation

Till plain: forms behind an end moraine; features unstratified coarse till, has low and rolling relief, and has deranged drainage pattern.

Outwash plain: beyond moraine deposits; stream channels that are meltwater fed, braided, and overloaded with sorted materials.

Esker: sinuously curving narrow ridge of coarse sand and gravel. Forms along a channel of a melt-water stream that flows beneath a glacier, in an ice tunnel or between ice walls.

Roche Moutonnée: an asymmetrical hill of exposed bedrock. Gently sloping an polished on it upstream side, abrupt and steep on downstream side from glacial plucking.

Kettle: ice let over leaves a dent in the land and creates a small lake with melt water

Kame: small hill, knob, or mound or poorly sorted sand and gravel that is deposited directly by water, by ice crevasses, or ice-caused indentations in the surface.

Drumlin: deposited till that has been streamlined in the direction of continental ice movement, blunt end upstream and tapered end downstream.
-Peterborough has a large area of drumlins that were created during the Wisconsian glacial era.

Geography of Permafrost

Permafrost: when soil and rock temperatures remain below 0 C for at least two consecutive years

- areas not covered by glaciers, are considered to be periglacial
- criteria to classify is based on temperature, nothing to do with amount of frozen water present
- as much as 50% of Canada and 80% of Alaska are permafrost conditions.

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Continous permafrost: region of severest cold and is perennial, roughly poleward of the -7 C mean annual temperature isotherm.

- affect all surfaces except those beneath deep lakes or rivers

Discontinuous Permafrost: gradually coalesce poleward toward the continuous zone

- scattered or sporadic until it gradually disappears.
- Bounded by the -1 C isotherm
-

Ground-ice and Frozen-ground phenomena

Ice wedge: forms when water enters a crack in the permafrost and freezes

- repeated seasonal freezing and melting progressively enlarge the wedge.
- Widening may be small each year but can build up over time

Frost-action Landforms

Pingo: large areas of frozen ground can develop a heaved-up, circular, ice-cored mound.

- occasionally exceeds 60m in height
- result of pressure from expansion as water turns to ice.

Palsa: rounded or elliptical mound of peat that contains thin perennial ice lenses rather than an ice core.

- 2-30m wide and 1-10m high
- covered in soil and vegetation

Patterned ground: unique synergies at work. Expansion and contraction of frost action result in a movement of soil particles, stones, and small boulders.

- as debris moves, stones move toward stone domains and soil moves to soil domains. Creating patterns and areas of different concentration of materials.

The Pleistocene Ice-age Epoch

Ice age (glacial age): applied to any extended period of cold, which may last several million years

- constists of glacials, cold climates, interrupted by interglacials, warmer periods, inbetween.
- Pleistocene: an epoch of the late Cenozoic era in which ice covered most of the northern hemisphere.
- Prolonged cold period in Earth history, 1.65 million years ago to about 20 000 years ago
- Consisted of at least 18 periods of expansion and melting of glacial ice over the northern hemisphere
- Expansion of ice happens slowly (approx 100 000 years) while melting happens rapidly (around 10 000 years)

Changes in Landscape

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- continental ice sheets covered most of Canada, protions of US, Europe and Asia, about 18000 years ago.
- As thick as about 2-3km
- Retreating alpine and continential glaciers exposed drastically altered the landscape across the country. Sawtooth range and tetons in Idaho and Wyoming, the scenery of the Canadian Rockies, the Great lakes , the Matterhorn, etc.
- Ice expanded and contracted in Great Lakes to make great basins to form the lakes.

Temperature changes

- Earth climates have fluctuated slowly until the past 1.2 billion years.
- Temperature patterns of 200-30o mil years began pronounced
- Pleistocene Epoch began 1.65 mil years ago any may still be in progress
- Holocene Epoch started 10,000 years ago with a sudden increase of 6 C

Mechanisms of Climate Fluctuation

- Climate and celestial relations: the rotation of the earth around the sun and on its axis all play a part in temp change
- Solar Variability: sun varies its output over the years
- Plate tectonics: some land masses have migrated to higher and cooler latitudes.
- Ocean circulation: changes in patterns may slightly change the temperature of climate.

Arctic Region: 10 C isotherm for July defines the arctic area; coincides with visible tree line, that boundary between forests and tundra

- consists of floating sea ice (frozen sea water) and glacier ice (frozen freshwater)

Antarctic region: narrow zone that extends around the continent as a boundary between cold Antarctic waters and warmer waters of southern hemisphere.

- isotherm is 10 C in February
- Area covered in sea ice is bigger than North America, Greenland and Western Europe combined.

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