Plate tectonics

Lithosphere	7 major and 8 minor lithospheric plates. On average plates are 125km thick, oceanic 50-100km and continental up to 200km. Made up of the crust and upper mantle it is classified as a solid. Continental crust is feldspar and quartz making granite whilst oceanic is basalt.
Moho	Underneath crust. Rich in iron and magnesium - peridotite. Upper mantle of Earth.
Plate boundaries:	
Divergent	New lithosphere is created as plates move away. Oceanic plates create ocean ridges or rises. Continental plates create rift valleys. Decompression melting as plates move away. Produces basal. Magnetic stripes help to show movement.
Convergent Boundaries:	
Oceanic/continental	Oceanic plate subducts under. Both plates fracture and deform. Shallow earthquakes creating Benioff zone. Sediments on top of crust create accretionary wedge. Flux melting occurs creating andesite.

Plate tectonics (cont)

Continental/-continental	Creates large mountain ranges of folded rock. Earthquakes are common in these areas.
Oceanic/oceanic	Volcanic islands form on a volcanic arc. Made out of andesite and andesite which was created through flux melting.
Conservative boundary	No volcanic activity. Extensive shallow earthquakes which can occasionally have high intensity.
Hotspot	Caused by mantle plumes which originate at outer core. Create shield volcanoes.

Uniformitarianism

The laws of physics have applied wherever and whenever events occurred. Long gradual processes that are interrupted by catastrophic events. Laws of stratigraphy can be applied.

Venus	Similar size and structure to Earth, extreme surface pressure and heat, runaway greenhouse effect, extensive volcanism, potential life.
Mars	Most "Earthlike" body in our solar system, realistic host of life until loss of magnetosphere, volcanism, evidence for fluvial and lacustrine processes occurring.

Uniformitarianism (cont)

Places of interest:
4 Moons of Jupiter and Saturn as they contain evidence for conditions supporting life. In particular water or hydrosphere, building blocks of life and an energy source.

Io	Most volcanically active, 100s of volcanoes, tug of war between Europa and Ganymede.
Europa	Most promising for life, icy surface over water, water vapour detected.
Enceladus	Icy crust exhibiting liquid water, some water jets have hydrocarbons salts and organic materials.
Titan	Bigger than moon and mercury, only moon with a nitrogen atmosphere, mercury in liquid form

Mineral identification

Identification is done by the physical properties of the mineral.

Lustre and colour	The type of reflection of light. Metallic, submetallic, non-metallic glassy. Colour can be misleading due to variations in minerals. Some minerals only display one colour.
Streak	Colour of the ground mineral. More useful than colour.
Hardness	The ability to scratch other substances. Diamond is a 10 and a steel knife at 5.5 splits hard and soft minerals.

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Not published yet.
Last updated 4th July, 2022.

Mineral identification (cont)

Habit	The pattern in which crystals grow. Anhedral crystals are constrained so cannot form properly. Subhedral are partially formed and euhedral are perfectly formed. Some minerals have multiple habits.
Cleavage and fracture	The way in which a mineral breaks. Arises when certain bonding is weaker than other parts. Some minerals have stronger cleavage and others fracture.

Atmosphere

Water vapour is the most abundant greenhouse gas in the atmosphere however carbon dioxide, methane and nitrogen are other notables. Thermal radiation is absorbed as it reflects off the earth and is stored in the gases. Atmospheric density and thus pressure decreases with height.

Layers of the atmosphere from surface going up are troposphere, tropopause, stratosphere, stratopause, mesosphere, mesopause thermosphere. Temperature decreases up to the tropopause. Weather occurs in the troposphere and aircraft fly in the tropopause. The stratosphere has a temperature that increases with height and contains the ozone layer. The mesopause has a decreasing temperature with height. The thermosphere has temperature fluctuations and is where auroras occur. Beyond is the exosphere which is the upper limit to the atmosphere. Different molecules in different layers absorb different UV rays.

Atmosphere (cont)

Global circulation:
Differential heating is caused by the curvature of the earth thus causing different amount of the sun's radiation to hit areas. Greatest heating is at the equator. Polewards of 40 degrees latitude more radiation exits then enters causing global circulation.

Atmospheric cells:
Nearest the equator are the Hadley cells which extend up to the tropopause. They have rising heat from the equator spreading to the poles where it gradually sinks. The polar cells are the smallest and extends to 60-70 degrees latitude. As air laves poles it warms and rises before returning to poles. Ferrell cells sit in between and flow in opposite direction and are not temperature driven. Rising air creates low pressure leading to raingall., sinking air high pressure leading to deserts.

Coriolis effect:
Apparent motion to the right in Northern hemisphere and left in Southern. Earth rotates faster at equator rather than poles. Causes wind to move in a curved direction. As air moves in the Hadley cell it curves and speeds up. By 30-40 degrees latitude it is moving eastward at 12-15 kilometres height called Jetstream. Polar front jet marks difference between cold polar air and warm tropical air. Sits at 11-13 km and result of temperature contrast. Tradewinds are another effect of Coriolis but is the air from the Hadley cell moving towards the equator. .

Bowen's Reaction series

Description of temperature at which minerals crystallize. 700 degrees is the temperature most minerals exist as solids whilst 1250 degrees is the opposite. This is for 1 bar of pressure.

Bowen's Reaction series (cont)

Right hand column shows compositional categories with ultramafic at the top. Down arrows shown increase in silica, sodium, aluminium, and potassium as you near felsic and magnesium, iron and calcium as you near mafic. Minerals near the top crystallize at higher temperatures.

This temperature difference can explain why certain minerals always crystallize together.

Rising sea level

Key issues:
-Where will sea level refugees go?
-What happens to trade when island nations disappear?
-What happens to coastal groundwater?
-What is connection between flooding, infrastructure and storm severity in coastal cities?
-What is the effect of mangrove destruction?
-What feedback loop is there between ocean rise and global temperatures?

Potential solution:
-Social protection
-Livelihood diversification
-Hazard-proof housing and infrastructure
-Ecosystem measures to reduce flooding
-Mangroves to reduce storm energy
-Reservoirs to buffer low-flows and water scarcity
-Coastal retreat and resettlement
-Risk sensitive land use planning
-Early warning systems and evacuation

Volcanism

Volcanos mainly occur on tectonic plate boundaries but occasionally occur in the middle of plates.

Mid ocean	Most common. Slow, gentle oozing eruptions creating basaltic pillow lava. Hydrothermal vents called black smokers.

Volcanism (cont)

Subduction	2nd most common. Flux melting causes eruptions of mostly silica rich rocks. Andesite, rhyolite, pumice and tuff.
Rift	Basaltic lava, flood basalts, cinder cones.
Hotspots	Mantle plume below volcanos variety of magmas.
Volcanos:	
Shield	Largest volcanos. Broad low angle with mafic magma chambers. Typically MOR, hotspot or continental rift. Built up from numerous low viscous eruptions. Fissures can occur with magma erupting.
Strato-volcano	Steep flanks, distinct crater and prominent rise. Alternating pyroclastic and lava layers. Felsic to intermediate chambers. Viscous flows with explosive eruptions.
Domes	Accumulation of silica rich magma that cannot move far from eruption. Often form in collapsed stratovolcanos.

Volcanism (cont)

Caldera	Steep walled, basin shaped depressions formed by collapsed magma chambers. Commonly used to describe a volcano with high viscosity and volatile eruptions.
Cinder cones	Small volcanos with short eruptions of cinders and volcanic bombs. Violent eruption, cone formation, flow from base.
Flood basalts	Lowest viscosity event, may be the cause of mass extinction events.
Carbon-atites	Rift valleys, carbonate based magma, over 50% carbonate with low viscosity and temperature.
Hazards and monitoring:	
Pyrocl-astic flows	Most dangerous hazard. Mixture of hot rock and gas with high speeds. Most composite volcanos have flows.
Landslide and tsunami	Slope failure can occur which can lead to landslides and eruption events. If enough material reaches the ocean a tsunami may be triggered.
Tephra	Ejected rock material. Hot ash can disrupt air travel, and cause building collapse.

Volcanism (cont)

Volcanic gas	As pressure decreases gases may escape. Non erupting volcanoes may emit gases. Some gases sink which can cause increased risk
Lahars	Volcanic mudflow resembling wet concrete. These can reach large speeds.

Slow release causes small eruptions sudden release causes explosive.

Ocean circulation

Density difference is a driving factor of ocean movement. Temperature and salinity are two big effects on desnity.

Temper ature	Temperature of water is highest at the equator where most heat is absorbed. Warmed water moves towards the poles.
Salinity	Salt concentration varies ocean to ocean. North Atlantic has some of the highest.

Water generally is denser at poles and lighter at equator. This means water sinks at poles and rises at equator. The layers of water only mix in certain areas.

Ocean currents are masses of water in motion and come in two main types wind-driven and thermohaline.

Surface currents:
Primarily driven by wind and help atmosphere move heat from equator to poles. Warm surface currents move to the poles whilst cold move to the tropics. Coriolis effect causes movement to the west of each basin. Flows clockwise in the north and anticlockwise in the south. Driven by tide wind and shape of land.

Ocean circulation (cont)

Thermohaline currents:
Deep below the surface the currents transport cold saline water. When winds blow across ocean surface upwelling occurs which brings dense water up.

Global conveyor belt brings dense water from North Atlantic across ocean floor to south Atlantic through the Indian ocean before reaching the pacific where it mixes with the surface currents. This can take thousands of years.

Transport processes

Gravity	Angular, poorly sorted, usually further transportation,
Wind	Angularity is distance from the source. Sorting related to water velocity.
Water	Well rounded and frosted, well sorted.
Glacial	Indiscriminate angularity, completely unsorted, diamict.
Mud flow	Angularity decreases with distance, very poorly sorted, behaves like concrete,

Metamorphic rocks

Metamorphic rocks are rocks that have been changed by heat, temperature and/or fluid. Occurs when solid rocks changes composition or texture without melting. The rock that undergoes metamorphosis is called a protolith.

Temperature:
Increase in temperature means increase of energy. As energy increases there becomes a potential for atoms to swap within the solid lattice. Heat metamorphism can occur at temperature between 200-700 degrees possibly reaching up to 1,100.

Metamorphic rocks (cont)

Pressure:
There are two groups of pressure confining pressure and directed stress. Stress is a force whilst strain is the result. Confining pressure has equal pressure from all directions. pressures range from 3,000 bars to around 50,000 bars, which occurs around 15-35 kilometres deep. Directed stress has unequal pressures causing deformation. Occurs at lower pressures and causes mechanical change.

Fluids:
Chemically reactive fluids enter the rock and can change the composition. It can incorporate surrounding rocks into the protolith. This is commonly called hydrothermal metamorphism. MOR

Metamorphic textures:
Texture is the description of the shape and orientation of grains.

Foliated	Minerals lined up in planes. Appear like the minerals are stacked like pages of a book. No common direction
Lineated	Lines of minerals that point in a common direction.
Non-foliated	No lineation, foliation or alignment of minerals. Usually only contain one type of mineral.

Metamorphic grade:
Metamorphic grade refers to how much the rock has changed. Low-grade metamorphism starts just above sedimentary conditions. Slate→phyllite→schist→gneiss shows increasing metamorphic grade. Index minerals can be used to identify the protolith and conditions.

Metamorphic environments:
{{nl}}Metamorphic facies are a set of minerals that show metamorphic conditions.

Metamorphic rocks (cont)

Burial	Occurs when rocks are buried below 2000km. Occurs in sedimentary basins and a extension of diagenesis. Low grade metamorphism.
Contact	High temperatures and low pressures. Hot magma intruding on a protolith. Different pressure produces different facies.
Regional	Increased temperature and pressure over large areas. Often in mountains with continental convergence. Lowest grade on flanks, highest in core. Foliated rocks.
Subduction	Regional metamorphism that occurs as a plate subducts. High pressure low temperature.
Fault	Faults create rock flour from constant grinding. Creates fine grained rocks.
Shock	Metamorphism resulting from a meteor or bolide impact. Creates a range of products.

Exhumation:
The processes which bring the rocks to the surface.

Orogenesis	Lower portion of the crust gets warm and weaker before collapse. Crustal thinning letting rocks get closer to surface.
Erosion	Surface erodes away which thus exposes deeper rock.

Laws of stratigraphy

Superp-osition	In sedimentary terms oldest layers are at the bottom
Original horizo-ntality	Sediments are deposited horizontally, meaning tilted layers were one horizontal.
Lateral continuity	Rock layers are laterally continuous and can be broken up by later events.
Cross--cutting	Cutting features are younger than the surrounds
Inclusion	The included piece of matter is older than the surrounding material
Fossil sucession	Fossils have evolved in a fixed timeline and once a species has gone extinct it cannot reappear in younger rocks.

Weather

Wind is created by differences in pressure. Low pressure systems are created by heating causing molecules to rise, and high pressure is caused by cooling causing molecules to sink. Wind is the movement of air from high to low pressure.

Hotter air has higher saturation point which is the largest amount of water the air can hold without precipitating.

Clouds form when air masses rise and cool enough to reach saturation. Air must be warmer than the environment to rise or be forced upwards.

Orographic lifting:
Mountains force clouds upwards. Precip-itation of windward side, rain shadow on leeward.

Weather (cont)

Convective lifting:
Localised heating, small convective cell, localised thunderstorms, small amount of precipitation.

Convergence lifting:
Winds converge towards centre of low pressure, clouds and precipitation, stronger convergence means stronger effects.

Frontal lifting:
Meeting of two air masses with different temperatures, different behaviours based on which mass moves in.

Cold fronts	Steep slopes, strong centred winds, clouds, thunderstorms precipitation.
Warm fronts	Diffuse clouds, spread out showers.

Fronts move through quickly.

Hydrosphere

The water cycle is the continuous cycle of water in the atmosphere. Evapotranspi-ration is the mix of evaporation from water bodies and transpiration from plants. Condensation is the vapour forming droplets and precipitation is the droplets leaving the sky. This water can move into bodies of water or infiltrate the ground an become groundwater.

Water basins are areas which catch precip-itation and channel it into a certain area. Drainage divides are topographical high points which separate these areas. Each stream or tributary has a basin. Smaller streams combine and the end is called the mouth. Some streams end in closed basins where only outflow is evaporation.
Perennial streams flow year round in high humidity and rainfall areas. Ephemeral only flow during wet periods. Water budgets compare incoming and outgoing water for certain areas.

Hydrosphere (cont)

Surface water:
Streams are rivers of water confined to a channel, they erode and transport sediment. Gradient and velocity are big factors of erosion. Increase gradient and velocity increases erosion.

Discharge	The volume of water flowing past a point in the stream over a defined time interval. Discharge increases down stream and with stream size.
Velocity	Velocity varies with shape, width and depth. Narrower streams and heavy rain events increase velocity. In curves highest velocity is on the outside of the bend, whilst straight it is in the centre at the top.
Drainage patterns	Dendritic patterns are random tributaries and occur in flat areas. Trellis drainage occur where rocks have been tilted and have various strength. Rectangular patterns occur in areas with bedding planes, joins and faults. Radial patterns occur when water flows away from a high point. Deranged occurs in areas of high limestone with subter-ranean drainage.

Hydrosphere (cont)

Fluvial processes:
Dictate how a stream behaves. These impact velocity, sediment, and gradient. Longitudinal profiles of the stream show base level over a distance.

Sediment production	Located at headwaters where rills and gullies erode sediment. Steepest part of the stream and small channels.
Sediment transport	Moves sediment from headwaters to ocean. Transport is related to velocity and gradient, higher gradients and velocities mean larger sediments. As velocity slows larger sediments settle. Large particles are the bedload and move along the bed, smaller sediments are the suspended load, while the smallest are dissolved load commonly from chemical weathering.
Floodp-lains	Flat land adjacent to a stream which floods regularly. Velocity is greatest when river is full, if it overflows velocity decreases and sediment is deposited.

Hydrosphere (cont)

Sediment deposition	Occurs when velocity decreases to a point where the load cannot be transported. Deltas and oceans.

Fluvial landforms:

Channel types	Straight - near headwater, low velocity & discharge, steep, narrow. Braided- multiple channels, low gradient, high sediment areas. Meandering- Single channel snaking across a flood plain. Outside edge is cut bank with high erosion, inside point bar with deposition.

Meander channels are confined by natural levees. These can isolate and direct flow. Isolated streams are called yazoo streams.

Meander landforms	Crevasse splays- breaking of levee causing deposition in flood plain. Oxbow lake- Forms when part of the channel is cut-off, eventually becoming a meander scar.
Alluvial fans	Occurs when stream leaves a valley causing sudden spread and velocity drops. Sediment depositon.
Delta	Occurs in quiet waters where deposition is greater than erosion.

Hydrosphere (cont)

Stream terraces	Old flood plains located above current flood plain and stream.

Groundwater:

Porosity and permea-bility	Porosity is the water holding space between grains. Permeability is the connectivity of these openings. Porosity reduces during cementation and compaction. Hydraulic conductivity measures above plus the fluid involved.
Aquifers	A good aquifer has high porosity and permeability. They can vary is scale and depth.

Groundwater flow:
As water infiltrates it enters the vadose zone which has a mix of water and air in the pores. It sits above the saturation zone. Below the vadose is the capillary and saturation zone which have water filled pores. Wells are conduits that extend into the ground and can be used to extract, measure and add water to aquifers. The water table is the area with its pores fully saturated with water.

Percolation varies with vegetation, rock type, rock fractures, soil type and moisture. Completely dry soil is hydrophobic.

Confining layers	Layers above or below aquifers that constrict flow of water. Aquicludes completely stop water whilst aquitards slow.

Hydrosphere (cont)

The potentiometric surface is the level which water would rise to in a penetrating well. Water table generally mirrors surface level however if it intersects there will be water on the surface. Gaining streams lie above the water table and gain water, while losing streams lie below and lose water. Pumping water from a unconfined aquifers lowers the water level producing a cone of depression. Pumping water from confined aquifers lowers the potentiometric surface.

Recharge and discharge:
Recharge is when surface water enters the table through infiltration. Generally topographically high locations with vegetation. Discharge areas are where the water table or potentiometric surface intersects the surface.

Groundwater mining:
Freshwater is finite and the only natural source is precipitation. When water is extracted faster than it is replenished. Called groundwater mining and leaves the possibility that water runs dry. Reduce is pore pressure can cause collapse called subsidence.

Water contamination:
Water can be contaminated by natural and human processes. Point source contamination occurs at a single source while nonpoint occurs at many. Point sources include sewage facilities and dumps whilst non point are nutrients from farms and fertilisers from neighbourhoods. Remediation is the act of cleaning contaminants.

Karst:
Landforms created by water dissolving limestone. Carbonic acid dissolves the calcite creating karsts.

Weathering & Erosion

Water has polarity due to the oxygen on one side and hydrogen on the other. This creates adhesion and cohesion. Universal solvent dissolving more substances than natural liquid.

Weathering is the process of turning bedrock into sediment. Mechanical weathering is pressure, frost, roots, salt. Chemical is carbonic acid, hydrolysis, dissolution and oxidation. Resistance is important in features.

Mechanical weathering:

Pressure	Uplifting of rock causes sudden pressure change but no temperature change. Causes rock to expand and crack. Exfoliation is when they come of in sheets.
Frost	Water works its way into cracks. As water freezes it expands causing rock to push apart. Repetitive cycles cause change.
Root	Roots work their way into cracks. Rhizolith if it becomes fossilized. Tunnelling organisms can have similar effects.
Salt	Evaporation of saltwater causes salt to precipitate. Crystals expand into rock.

Weathering & Erosion (cont)

Chemical Weathering:
Dominant weathering in warm humid environments. Occurs when reactants break rocks down into water soluble ions. Only works on surface. SA:Vol, more weathering, faster weathering occurs.

Carbonic acid Hydrolysis	Carbonic acid naturally created in clouds. Hydrolysis is carbonic acid ionizing water and replacing mineral cations in lattice. Carbonic acid can also directly react with minerals high in silica and aluminium. Hydrolysis is the main processes for silicate rocks and creates clay minerals. .
Dissolution	Dissolution is hydrolysis but the ions stay in the solution. Water dissolves any rock, more acidic = quicker. Dissolution series states that minerals higher on Bowen's series more prone to weathering. Areas with high carbonate may produce karsts.
Oxidation	Reaction causing iron to rust. Any rock with iron may oxidize. May cause oxide to permeate the rock causing weaknesses.

Weathering & Erosion (cont)

Erosion	Mechanical processes driven by water and gravity. Removes sediment from place of weathering. Different erosion resistant created Grand Canyon.
Soil	Combination of air, water, minerals, and organic matter that forms at the transition between biosphere and geosphere. Organisms turn sediment and the minerals within into organic substances. Organic material in soil is humus.

Magma generation

Magma contains three components melts, solids and volatiles and the abundance can effect the behaviour of the magma.

The geothermal gradient is how much the temperature increases as you enter the earth. In the upper 100km it is roughly 25 degrees/km. The solidus is where rocks begin to melt. Naturally 125km is the closest the geotherm and solidus come.

There are 3 main ways to make rocks melt. Decompression melting, flux melting and heat-induced melting. As minerals melt at different temperatures most of the time it is partial melting.

Magma generation (cont)

Decompression	Mainly occurs at mid ocean ridges and hotspots. Crust is a bad conductor of heat so temperature of magma stays the same. Convection currents push magma up as plates move apart. Hotter magma at lower depths.
Flux	Mainly occurs in island arcs and subduction zones. Volatiles are added to mantle which decreases its melting point.
Heat-induced	Mainly occurs at mantle plumes or hotspots. Some decompression melting is involved as magma moves towards surface. Extreme heat is applied from plume.

Partial melting is important when dealing with the mantle. Silica rich portions of mantle melt first which means the magma gets increasingly rich in silica.

Magmatic differentiation changes the chemistry of resultant rocks towards felsic compositions.

Assimilation	Incorporation of surrounding rocks into the magma.
Fractionation	As temperature drops mafic minerals crystallize and settle to the bottom of magma chamber creating a more felsic composition.

Mineral formation

Different minerals form in different conditions. Temperature, pressure, composition and environment all effect which mineral will form. This information can also be used in reverse to find out what conditions certain areas must have.

Mineral formation (cont)

Minerals can help to tell us temperature, pressure of areas. In certain scenarios water temperature, degree of diagenesis, burial depth and magma qualities.

Examples of particulars are age of Earth, volcanic events, thermal history, deformation events, extinction events, lunar samples, ore/oil deposits.

Most important for rocks are carbonates and silicates while ore is oxides and sulphides.

Noble gases and actinides are the least useful elements in minerals.

Minerals

Minerals are naturally occurring crystalline solids that are formed by geological processes. They are homogenous elements or compounds which can be defined by a chemical formula.

Minerals have different varieties that are based of colour, occurrence or crystal shape. This variance can be caused by small amounts of transition metal ions.

Gems can be artificially created and be very similar to naturally occurring minerals.

Crystalline	having an orderly and repetitive structure

Naturally occurring non crystalline substances can be called amorphous solids and can be categorised as mineraloids. An example is obsidian.

Biominerals	Minerals produced by a living organism
Anthropogenic	Type of mineral that only exists due to human activity
Polymorphs	Crystals with the same chemical formula but different structure

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Not published yet.
Last updated 4th July, 2022.

Minerals (cont)

Rocks are made up of minerals. Minerals are made up of elements. Some minerals have variations that occur in nature.

Crystalline rocks occur when minerals crystallize together. Usually this is magma, metamorphism or precipitation. Clastic rocks form when minerals are cemented together.

Dana system of mineralogy categorises minerals based off chemical composition. From these classes there are many smaller divisons.

Some minerals can have substitutes that are chemically similar which can be switched out.

The main formation of minerals is precipitation from aqueous solutions, crystallization from magma, and biological precipitation.

Aqueous	Occurs when saturation is reached due to temperature drop, or changing chemical conditions.
Magma	The ions in the magma cool and crystallize forming minerals.
Organic	Organisms precipitate minerals and when they die they build up.

Sedimentary Rocks

Two main categories are clastic and chemical. Clastic rocks are made from broken pieces of bedrock and sediment derived from mechanical weathering. These are classified by grain shape, size and sorting. Chemical are precipitated from water saturated with dissolved minerals.

Sedimentary Rocks (cont)

Lithification and Diagenisis	Lithification turns sediment into clastic rocks through three steps. Deposition occurs when friction and gravity force sediment to settle. Compaction occurs as the sediment build up creating pressure. There is also weak attractive forces aiding this. Finally minerals from ground water cement the rocks together. Diagenesis is the accompanying process which is low temperature metamorphosis.

Clastic rocks:
Mostly mechanically weathered sediment, some chemical.

Grain size	Grain size is a classifying factor which looks at the average diameter. Large fragments are larger than 2mm and include boulders, cobbles, granules, and gravel. Silt is the lower end.

Sedimentary Rocks (cont)

Sorting and rounding	Sorting describes the size range withing the rock. Well sorted is a small range whilst poorly sorted is the opposite. This can help to identify deposition energy. Rounding occurs when angular corners are removed by abrasion. Roundness indicates transport length and mineral hardness.
Composition and provenance	Composition is the mineral components found in the rock. Commonly found are quartz, feldspar and lithic fragments. Provenance analyses composition and texture to try and identify the source of the sediment.

Clastic rocks are classified according to grain size. Conglomerates are rocks containing coarse rounded clasts, while breccias are angular clasts. Both are usually poorly sorted. Medium grains containing mostly sand are sandstone and arenite is well sorted. Fine grains are mudstone if they separate into sheets then shale.

Chemical, biochemical and organic rocks:
Chemical rocks are rocks that do not involve mechanical weathering or erosion.

Sedimentary Rocks (cont)

Inorganic chemical	Rocks formed when minerals precipitate out of a solution. Form salts called evaporites. Tufa is a calcium evaporite. Chert is silica precipitated from groundwater.
Biochemical	Form from ions dissolved in a solution however relies on organisms to extract from solution. Main formation of limestone.
Organic	Organic pieces of material preserved in geologic record. Follow similar processes to sedimentary rocks.

Classified based on mineral composition. Limestone is an exception. Rocks containing halite are rock salts. Calcite fizzes in acid.

Sedimentary structures are visible arrangement or textures in a rock. Use uniformitarianism to compare past to present.

Bedding planes	Layers denoting change in deposition conditions. Displayed as lines. Varves are repetitive cycles of deposition
Graded bedding	Refers to a change in grain size. Develops with a change is deposition energy.

Sedimentary Rocks (cont)

Flow regime and bedforms	Sand is the most easily moved grain size by fluids. Bedforms are the structures created by the process. Flow regimes are divided in upper and lower. Upper signifies faster movement. Plane beds created in lower regime similar to bedding planes. Ripples are small rises and falls created by deposition of sediment. Dunes are large ripples, large cross bedding structure. Anti-dunes occur in high flow regime and is sediment settling in small indents.
Bioturbation	Organisms burrowing through soft sediment. Occurs mostly in shallows.
Mudcracks	Clay rich sediment that has dried out. Crystals shrink causing cracks which fill with sediment. Tidal flats.

Sedimentary Rocks (cont)

Sole marks.	Small features denoting flow direction or up. Flute casts are carved out by flow, groove casts are carved out by debris. Load casts are heavier sediments on softer sediment.
Imbrication	Large clasts aligned in flow direction. Common in alluvial fans.
Geopetal	Used to identify which way was up when rock formed.

Depositional environments:

Marine	Abyssal plains have flat floors and most sediment is fine grained. Exception are submarine fan and turbidite. Lowe shoreface not effected by daily waves but effected by abnormal. Upper shoreface has well sorted fine sand.

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Not published yet.
Last updated 4th July, 2022.

Sedimentary Rocks (cont)

Coastline	Beaches consist of homogenous well sorted sand grains that are highly weathered. Tidal flats have areas of fine sediment but may contain coarse sediment. Reef have fine mostly carbonate sediments. Lagoons are areas of water separated by some features usually fine grained sediment. Deltas are places rivers meet sea and deposit sediment.

Sedimentary Rocks (cont)

Terrestrial	Fluvial(river) have meandering and braided varieties. Meandering has a single channel and mostly fine grained material. Braided usually have coarser sediments. Alluvial fans have intermittent water flow that can change sorting. Lacustrine (lake) have well sorted fine sediments. If evaporation outpaces precipitation a playa may form. Paludal have high organic matter. Aeolian is a deposit of windblown sediment. Fine grained and well sorted. Glacial is the worst sorted and so large it may create many environments.

Flooding

Occurs when naturally dry areas are covered by water. Riverine flooding is main flooding in Australia and occurs when ground is saturated and there is increased rainfall. Flash flooding is the most dangerous.

Plastic pollution

Plastic can break down into microplastics due to weathering.

Garbage patches are created in gyres as currents circle and draw the plastic in.

Plastic pollution (cont)

Issues from plastic:
-8 Millions metric tonnes a year
-Breaks down
-Sea life(starvation, entanglement, drowning)
-# of particles increases when breaking down
-Microplastic enter food chain(toxicity, accumulation)

Potential solutions:
-Curb single use plastic use
-Improve garbage collection
-Improve point collection at river mouths
-Deploy large scale ocean cleaning projects

Droughts, bushfires and floods

Drought & heat:
Global weather cannot be controlled. Australia has little topography and its location means there are natural rainfall fluctuations. There is not enough glaciers to create meaningful snowpack or glaciers. Meteorological droughts are below average rainfall which causes well drop and vegetation drying. Agricultural means there is not enough water to maintain agricultural activity. Native plants will dry or die. Socio--economic droughts have impacts on water supply and community decline.

Bushfires:
Changes in weather can create bushfires that are hard to control. Wind can increase fire unpredictability. Increase in bushfires due to increase in dangerous fire days. Burns large trees and grasses.

Floods:
High rainfall that cannot be absorbed if large bushfires have come through. Vegetation destruction making it impermeable. Loss of topsoil. Overdevelopment increase impermeable surfaces.

Droughts, bushfires and floods (cont)

Potential solutions:
-Limit greenhouse emissions to reduce extreme weather
-Curb land clearing especially on steep slopes
-Rapid replanting after clearing or bushfires
-Harvest storm water, recycle water, water conservation, seawater desalination, porous pavement.

Igneous rocks

Igneous rocks form through the cooling of magma which causes crystallization of minerals.

Extrustive	Quickly cooled lava with small crystals. Often called vesicular rocks as gas bubbles can be trapped. Volcanism forms the volcanic rocks different lava form different rocks.
Intrusive	Large crystals that form below the surface. Plutonic igneous rocks. Euhedral interlocking crystals.

Igneous rocks can be classified in different ways. These include texture, composition, and rock body.

Texture:

Crystal size:
Phaneritic is the term given to coarse grain rocks that cool slowly. Aphanitic fast cooling rocks with small crystals. Substances that cool so quickly crystals do not form are not considered minerals but volcanic glass. Rocks with mixture of crystal sizes are porphyritic. Large crystals are phenocrysts whilst small are groundmass or matrix. Indicates multistage cooling. Pegmatites are created during very slow crystallization.

Igneous rocks (cont)

Other:
Magma contains gases dissolved in solution. These are called volatiles and as pressure decreases they bubble out of magma. These bubbles become trapped creating vesicles. Common vesicular rock is scoria. In explosive eruptions large particles will be thrown in the air which form pyroclastic textures.

Composition:

Refers to rocks chemical and mineral make-up. Igneous rocks are divided into felsic, intermediate, mafic, and ultramafic. These divisions sit on a continuous spectrum. Silica increases viscosity.

Felsic	High in feldspar and silica. Minor mafic minerals. 65-75% weight in silica and poor in iron and magnesium.
Intermediate	Roughly equal light and dark minerals. 55-60% range of silica.
Mafic	High in magnesium and iron and plagioclase feldspar. 45-50% silica.
Ultramafic	Poor in silica >40%. Rare on surface but make up upper mantle.

Rock Bodies:

Igneous rocks are common in the rock record. Intrusive rocks are more common as they aren't exposed to erosion as much.

Dikes	Intrusion of magma into a crack or fissure.
Sill	Exploits a weakness between sedimentary layers. Parallel to layers.

Igneous rocks (cont)

Pluton	A cooled diapir. Many merged together are a batholith.
Laccoliths	Upward bulge of magma between sedimentary layers. Downward is lopolith.

Weather vs Climate

Weather is single season temperature or rainfall variations. Climate is long-term variations or trends.

Australian climate influences:
Sea surface temperatures include the Pacific, Indian, and Southern oceans whilst other effects include Australian monsoon and Madden-Julian oscillation.

ENSO - El Nino-Southern oscillation:
Australian effects include reduced rainfall, warmer temperatures, shift in temp extremes, increased frost, reduced cyclones, later monsoon, increased fire in south, decreased alpine snow depth.

Climate change

Carbon dioxide and oxygen would have been important gases for early life on the planet. Snowball Earth would have reduced photosynthesis, volcanic explosion producing CO2 to heat Earth.

Carbon dioxide	76% emitted by human activity, residence time decades to centuries
Methane	More potent effect (25x CO2), residence is a decade, 16% human
Nitrous oxide	300x CO2, century residence time, 6% human caused emission
Fluorinated gas	thousands of times CO2, 10s of 1000s years, 2% human emission.

Climate change (cont)

Water vapour	Most abundant not linked to human activity.

Australia fuels many other countries fossil fuel emissions.

CO2 ppm is increasing on timescales that have never been seen before. Seasonally CO2 emissions vary due to increase of photosynthesis in northern summers.

Other controls on climate:
Albedo is the reflectivity on Earth largely effected by ice and clouds, water and land. Ocean chemistry and temperature. Orogenies- increased weathering means decreased CO2. Milankovitch cycles are natural orbital variations

Tipping points are points between two stables once it is crossed it is hard to go back to previous state.

Climate modelling is changing constantly due to improvements in technologies and changing variables.

Mineral groups

Silicate minerals are built around silicon-oxygen tetrahedra. These ions are a pyramidal shape with the silicon atom at the centre surrounded by 4 oxygen. The corners can bond with other silica tetrahedra or positively charged ions. Silicates are the largest mineral group.

Olivine $(Fe,Mg)_2SiO_4$	Primary mineral in mantle such as peridotite and basalt. Green when not weathered. Mafic mineral also ferromagnesian.

End members refer to minerals that can have substitutes and the pure varieties of each.

Mineral groups (cont)

Pyroxene $XZ(Al,Si)_2O_6$	Found in igneous and metamorphic rocks. Usually black or dark green colour. Built from polymerized chains of silica tetrahedra. X represents the ions Na, Ca, Mg, or Fe, and Z represents Mg, Fe, or Al. Substitutions are possible due to similar ionic size.
Amphibole	Double chain polymerized silica tetrahedra. Common long bladed crystal structure. Complicated chemical structure that causes a range of colours.
Sheet silicates	Sheets of tetrahedra with top corner open for bonding. Mica and clay common variants.
Framework Silicates	Silica tetrahedra framework with other ions filling holes. Quartz and feldspar most abundant minerals in crust. Different varieties of feldspar occur due to the incapability of both potassium and calcium/sodium to be in the lattice.

Non-silicate minerals do not contain the tetrahedra. They are commonly economically important.

Mineral groups (cont)

Carbonates	Calcite and dolomite are most commonly occurring. Usually form due to lithification.
Oxide, halide, sulfide	Oxides are metal ions bonded with oxygen. Halide are the halogen bonded with cations. Sulfides are metals bonded to sulfur, important for mining.
Sulfates	Metal ion bonded to a sulfate ion.
Phosphates	Tetrahedral phosphate unit combined with anions and cations.
Native element minerals	Metals occurring in a pure or nearly pure state. Usually non-reactive elements.

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Not published yet.
Last updated 4th July, 2022.