Plate Tectonics and Volcanoes

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General Treatment of Plate Tectonics

- **Plate tectonics** - continental drift; creation and recycling of the Earth's crust and associated tectonic and volcanic activity
- Existed as the Earth develops its crust - 4 billion years
- **Pangaea** - a supercontinent that broke up 250 MYBP
- Continuous process
- Centrifugal movement of dispersal and coming together
- **Convective processes** - molten material comes up to the surface - **spreading centres** (where new ocean plates form)
- **Subduction zones** - area where the plates formed in the spreading centres comes back down into the earth's interior
- **Paleomagnetism** - the Earth's magnetic field changes causing the seafloor spreading where the layers of rocks moves away from the centre (the farther it is that older the rocks are)

Products of Plate Tectonics

- **Mountains** - what causes the mountains to form is the sinking in the subduction zones leaving elevated parts
- Linearity (linear volcanoes) where **hotspots** are formed - intense magma pressure underneath the plate

Impacts of Plate Tectonics

- Changes global **geography** and **topography**
- Controls the global carbon cycle hence the size of the Earth's greenhouse effect
- Rocks contain 90% of carbon, therefore, volcanic activity disperses the carbon content back into the atmosphere - influencing **atmospheric chemistry**
- Oceanic circulation - currents flow the way they do to keep the world in balance; constantly in contact with atmospheric circulation
- Every volcanic eruption which releases dust into the atmosphere stops incoming solar radiation - **atmospheric transparency** is influenced
- **Global biogeography** - Cretaceous-Tertiary boundary where the major mass extinction event occurred
- Regional differences in the biosphere is influenced by plate tectonics
    - Placentals, marsupials, and monotremes
    - Gymnosperms and angiosperms
    - Ratites
- All oceanic islands are volcanic and remote
- Islands have biotas that are unusual and vulnerable
- Climate change driven by plate tectonics constrained human evolution and the diffusion of people around the globe

Volcanic Activity and its Real and Potential Impacts on Society

- Occur in 3 different places: spreading centres (average), subduction zones (more destructive) and hot spots (least destructive)
    - Difference in power depends on their chemistries
- Amount of silica determines the violence of the eruption (more silica = more violent) - as it clogs the top which makes the components shoot up
- Environmental effects:
    - Tsunamis
    - Eruption in Tambora caused the "year without summer"

Book Readings: The Lithosphere and Tectonic System

The Earth's Structure

- The Earth is not uniform from its outer crust to its centre
    - Consists of central core with several layers with the densest matter at the centre
    - Formed by accretion from a mass of gas and dust orbiting the Sun
    - 6,400 km in radius
- Interior:
    - **Core** - 3,500 km in radius; 3000-5000 degrees Celsius
    - The outer core has the properties of a liquid and the inner core is in a solid state (under a very high pressure)
    - **Mantle** - rock shell composed of mafic minerals that is 2900 km thick
    - **Crust -** formed largely of igneous rocks
    - Moho - boundary surface between crust and the mantle
- Earthquakes produces three types of basic waves;
    - P wave (primary wave) - faster deep-seated wave; propagates by alternately pushing and pulling the rocks
    - S wave (secondary wave) - slower deep-seated wave; develops as it shears the rock sideways at right angles to the direction it is travelling
        - Speed of S and P waves depends on the density and properties of the rocks through which they pass
        - P waves are felt first in most earthquakes

        - The core's size has been determined by the distance at which S waves are detected
    - Surface waves
- Continental Crust
    - Consists of lower, denser zone of mafic composition, and an upper zone of less dense felsic rock
    - 2.7 g/cm^3 density
    - Commonly described as granitic rock
- Lithosphere and Asthenosphere
    - Lithosphere - composed of the crust and the cooler, upper part of the mantle
        - When lithospheric plates collide, they push together upwards to form mountain ranges
    - Asthenosphere - plastic layer produced by the brittle conditions of the lithospheric rock
        - Soft layer between the hard lithosphere and a strong mantle rock layer below

Geologic Time Scale

- Cenozoic Era - nearly all landscape features seen today has been produced in this period; subdivided into epochs
    - Radiometric dating - established the age of certain minerals within rocks using principles of radioactive decay

Major Relief Features of the Earth's Surface

- Relief Features of the Continents
    - Continents consist of two basic subdivisions; active belts of mountain-building and inactive regions of old, stable rock
        - Mountain ranges are formed through **volcanism** (accumulation of volcanic rocks) and **tectonic activity** (collision of lithospheric plates)
    - Alpine Chains - active mountain-building belts
        - Mountain arcs - broadly curved line characteristics in the world map representing alpine chains (circum-Pacific belt and Eurasian-Indonesian belt)
    - Continental Shields
        - Low-lying continental surfaces, beneath which are complex arrangements of ancient igneous and metamorphic rocks
        - Two classes of shields: exposed and covered shields
            - Exposed shields - very old rocks, mostly from the Precambrian Time and have a complex geologic history; regions of low hills and low plateaus (Canadian Shield - greatest area of exposed Archaean rock in the world)
            - Covered shields - areas of the continental shields that are covered by younger sedimentary layers from Paleozoic to Cenozoic eras
    - Mountain Roots
        - Formed with sedimentary rocks that have been intensely bent and folded
        - Caledonides - form a highland belt across the northern British Isles and Scandinavia

Midoceanic Ridge and Ocean Basin Features

- Midoceanic ridge - consists of submarine hills that rise gradually to a rugged central zone
    - The centre of the ridge is a narrow, elongated depression called the *axial rift*
    - The either side of the midoceanic ridge are broad, deep *abyssal plains* that belong to the ocean basin floor
- Continental Margins - narrow zone in which oceanic lithosphere is in contact with continental lithosphere
    - Continental rise - the ocean floor begins to slope gradually upward as the continental margin is approached from the deep ocean
    - Continental slope - floor the becomes much steeper in this area
    - Continental shelf - gently sloping platform with vertical relief of less than 20 metres at the top of the continental slope
    - Passive continental margins - margins of the symmetrical basins which have not experienced strong tectonic and volcanic activity
        - This is because the continental and oceanic lithosphere joining in the margin are part of the same lithospheric plate and moves away from the axial rift as a single unit
    - Active continental margins - deep offshore oceanic trench edges

Plate Tectonics

- Plate Motions and Interactions
    - Tectonic activity - describes all forms of breaking and bending of the lithosphere including the crust
    - The heat energy from radioactive decay of unstable isotopes in the crust and mantle moves the crustal plates
    - Subduction - the process in which one plate is carried beneath another; occurs because the oceanic plate is colder and denser than the asthenosphere through which it sinks
    - Magma solidifies into gabbro - same composition as basalt
    - Divergent (spreading boundary) - type of boundary between plates
    - Converging boundary - where oceanic lithosphere plate (thinner and denser) collides with the continental lithosphere plate
    - Transform boundary - two lithospheric plates are in contact along a common boundary wherein movement of the plates causes neither separation nor convergence
- Tectonic Processes (Compression and extension)
    - Compressional activity acts as a converging plate boundaries which results into an alpine mountain chain consisting intensely deformed strata
    - The strata are tightly compressed into wavelike structures called folds
    - Extensional activity occurs when tectonic plates pull apart

    - Overthrust faults - forming of faulting in which slabs of rocks are displaced along gently inclined fault surfaces
    - Thrust sheets - rocks slabs (nappes)
    - Orogens - entire deformed rock mass produced by compression (orogeny)
- Subduction Processes
    - Converging plate boundaries are zones of intense tectonic and volcanic activity