Chapter 2: Internal Structure of Earth and Plate Tectonics

Earth is layered and dynamic

* The internal structure of Earth can be considered in 2 fundamental ways:
  + By composition, state (solid or liquid) and density (heavy or light)
  + By strength (weak or strong)

Structural layers of Earth

* Inner core:
  + Solid inner core with thickness of 1300km
  + Temperature as high as the surface of the sun
  + Composed or iron (90% of the weight) and the rest of minor elements
* Outer core:
  + Liquid outer core with thickness of just over 2000km
  + Similar composition as the inner core
* Mantle:
  + 3000km think surrounds the outer core
  + mostly of solid iron-rich and magnesium rich rocks
* Crust:
  + Ranges from a few to 40km thick and is the outer rock layer of Earth
  + Mohorovicic discontinuity (Moho): separates the lighter rocks of the crust from the more denser rocks of the mantle below

Lithosphere

* Lithos means “rock”
* Cool, strong outermost layer of Earth
* Consists of the crust and the rigid part of the mantle

Asthenosphere

* asthenos means “without strength”
* constitutes all but the uppermost part of the mantle
* hot, slowly flowing layer of relatively weak rock

Continents and Ocean Basins

* crustal rocks are less dense than the mantle rocks below
* continental crust is slightly less dense than oceanic crust
* oceanic crust is also thinner than continental crust

Oceanic crust underlying today’s ocean basins is less than 200M yrs old whereas continental crust is up to several billion yrs old

Convection – the transfer of heat by the movement by particles

* earth’s internal heat causes magma to heat up and become less dense
* ex. Think of how a pan of water is heated. As the pan water is heated, less dense water rises from the bottom and displaces denser cooler water at the top, which then sinks down to the bottom

Knowledge of the Earth’s structure comes from seismology – the study of earthquakes and earthquake waves

Earthquakes cause seismic waves to move through Earth

* some move through solids not liquids
* some waves are reflected
* some waves are refracted (change direction)

Seismographs – instruments that record seismic waves

* wave movement has allowed scientists to deduce the structure on Earth’s interior and the properties of its layers

What have we learned about Earth from earthquakes?

* Magma is generated in the asthenosphere
* The existence of slabs of lithosphere that have sunk deep into the mantle
* The variability of lithosphere thickness, reflecting differences in its age and history
* What is liquid and what is solid

Tectonic – refers to the large scale geologic process that deform Earth’s lithosphere and produce ocean basins, continents, and mountains.

* Driven by forces deep within Earth

Lithospheric plates – lithosphere that is broken into pieces

* They move relative to one another
* Process involved in the creation movement and destruction of these plates are known as plate tectonics

Plate Boundaries are delineated by earthquakes and active volcanoes

* Over time, plates have formed and been destroyed, cycling materials from the interior of Earth to the surface and back into the mantle again – tectonic cycle
* Defined by areas of seismic activity
* Dynamic events on the Earth’s surface occur when plates move

Seafloor spreading

* Mechanism for plate tectonics
* At mid ocean ridges, new crust is added to edges of lithospheric plates (spreading centres) but then destroyed where one plate sinks beneath another at subduction zones
* The rate of production of new lithosphere at spreading centres is balanced by consumption of lithosphere at subduction zones

Sinking Plates generate Earthquakes

* Sinking ocean plates come in contact with the hot asthenosphere
* Magma is generated at the descending plate heats and releases fluids that move upward into overlying asthenosphere and lithosphere
  + Magma then rises to the surface and is erupted at volcanoes
* Earthquakes occur along the path of the descending plate – wadati-benioff zone

Convection within Earth’s mantle likely drives plate tectonics

Types of Plate Boundaries – broad zones of intense deformation

1. Divergent boundaries

* Where 2 plates move away from one another
* New lithosphere is created at these boundaries
* Divergence between 2 ocean plates causes mid ocean ridges and seafloor spreading

1. Convergent boundaries

* Where 2 plates collide head-on
* Oceanic-continental collision happens when one of the converging plates is oceanic and the other continental, result in subduction zone
* Oceanic-oceanic collision occurs where both of the converging plates are oceanic.
  + One plate subducts beneath the other giving rise to a subduction zone backed by an arc-shapes chain of volcanoes
  + known as an island arc
* Continental-continental collision, where both plates are continental, it is difficult for one to sink beneath the other because they have the same density.
  + Create high, faulted, crumpled like mountains
  + Ex.himalayas

1. Transform boundaries

* Occurs where the edges of two plates slide horizontally past one another
* The fault along which the movement takes place is known as the transform fault
  + Most common on ocean floor, but some occur within continents

In some places, 3 plates border one another – triple junctions

Ex. Juan de Fuca, north America and pacific plates off the NW corner of Vancouver Island

Rates of plate motion

* Plates move a few cm/year
* At central points the plates move at a steady slow rate, but movement may not be steady at plate boundaries
  + plates can displace by several meters during an earthquake, ex.

Magnetic stripes – scientists used ships to tow magnometers align the ocean floor to measure magnetic properties of rocks.

* Rocks on the ocean floor are magnetically striped parallel to mid-ocean ridges

Paleomagnetism – the study of the magnetism of rocks at the time their magnetic signature was acquired

Driving Mechanisms of Plate Tectonics

* Ridge push – gravitational push away from crests of mid-ocean ridges
* \*Slab pull – occurs when cool, dense ocean plates sink into the hotter, less dense asthenosphere. The weight of the plate pulls the plate along

Plate Tectonics & Hazards

* divergent plate boundaries exhibit earthquakes and volcanic eruptions
* boundaries that slide past each other have appreciable earthquake hazards
* convergent plate boundaries where one plate sinks, contain explosive volcano and earthquake hazards
* convergent plate boundaries where continents collide have high topography and earthquakes

Hot spots

* volcanic centres away from plate boundaries resulting from hot material from deep in the mantle
* magma moves up through the mantle and overlying plates
  + under oceanic and continental crust
* plates move over hot spots creating a chain of volcanoes