Topic F4: Key idea 2 – Plate tectonics

What is a lithospheric plate?

Lithosphere: the strong, outer mechanical part of the upper mantle and overlying crust, forming a rigid outer shell with its base marked by the 1300°C isotherm.

Asthenosphere: the mechanically weaker layer that underlies the lithosphere and over which it moves. This is evidenced by the seismic low velocity zone (LVZ) where temperatures near the melting point of mantle peridotite.

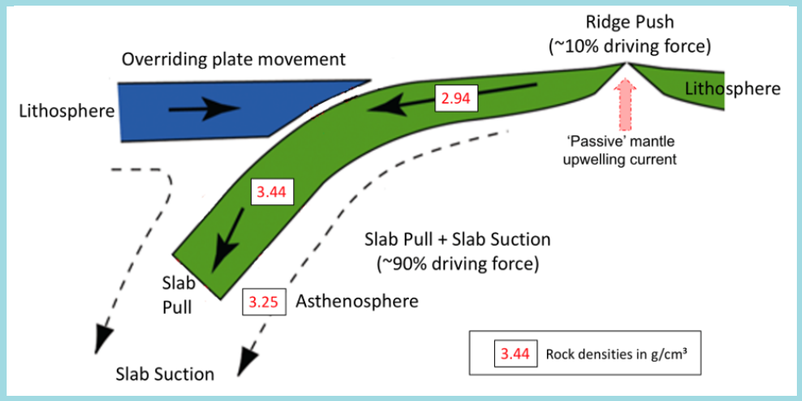
The plates interact at three types of plate boundary:

- divergent – plates move apart (e.g. oceanic ridges); shallow earthquakes/volcanoes (sea floor spreading)
- convergent – plates move together at subduction zones; shallow to deep earthquakes (Benioff zone) and volcanoes (island arcs and orogenic belts)
- transform (conservative) – plates slide past each other horizontally (shallow focus earthquakes).

Plate drivers

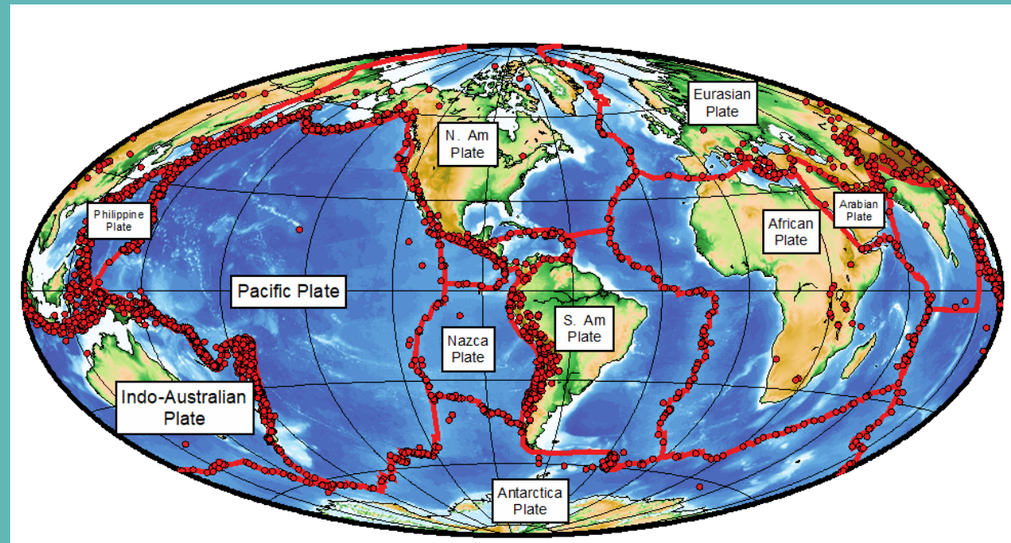
Possible mechanisms for plate movement involve density differences (slab pull) and gravitational forces (ridge push).

Plates are considered an integral part of the mantle convection system.



Evidence for plate tectonics

The outer mechanical shell of the Earth (lithosphere) is broken into a series of seven major and eight minor curved slabs, or plates, of various sizes in relative motion. These are relatively rigid but deform at the points where they are in contact with the plate boundaries.



Evidence comes from:

- direct measurements – ocean drilling and rock dating with GPS measurements
- global maps of the distribution of continents, volcanoes, earthquakes, oceanic ridges/trenches, orogenic belts and palaeoecological/ environmental zones
- seismic data (focal depth) at plate margins
- seismic tomography
- palaeomagnetic rock properties – magnetic stripes on the seafloor
- geothermal data (hot spots, heat flow).

Palaeomagnetism

Mafic rocks contain a record of the direction and inclination of the Earth's magnetic field (remanent magnetism) at the time of their formation.

Ferromagnesian minerals take on the direction of the Earth's magnetic field when their crystallisation temperatures fall below their Curie temperatures.

Palaeomagnetism can be used to determine changes of latitude as continents move with time.

Ocean floor anomalies (magnetic stripes) indicate sea floor spreading and rates.

Global geological processes

Various elements of the rock cycle are linked to plate tectonic processes:

- igneous – basaltic magmatism at oceanic spreading centres; basaltic and andesitic magmatism at convergent margins; granitic magmas in orogenic belts
- sedimentary – erosional processes and depositional environments are influenced by tectonic movements
- regional metamorphism – linked to plate subduction and orogenic belts.