Background information

Year 9, unit 2: Plate tectonics

The theory of plate tectonics has only emerged and matured as a widely accepted theory since the 1960s. This theory states that the Earth's outermost layer is fragmented into a dozen or more large and small solid slabs called tectonic (lithospheric) plates. These plates move relative to one another as they float on more mobile material (the asthenosphere) of the mantle.

The average rates of motion range from less than 1 cm to more than 15 cm per year. Nearly all the world's earthquake and volcanic activity occurs along or near boundaries between the plates.

The development of the theory of plate tectonics

In 1912, Alfred Wegener proposed his theory of continental drift. He suggested that the continents were once all attached in a single landmass he called Pangaea (Greek for 'all earth'). Over time, this mass broke apart and drifted to separate places on the globe. Evidence to support this included the shape of the continents, the existence of similar fossils on different continents, matching rock types and geologic structures and proof of ancient climate patterns.

Wegener's ideas were very controversial because he didn't have an explanation for how or why the continents moved. As a result, few people accepted his views and his theory was discounted.

In 1925, a German expedition found that a continuous mountain-like ridge runs through the Atlantic Ocean to the southwest of Africa. It was later discovered that the ridge was made up of many connected ridges that extend through the major oceans of the world and form a mid-oceanic ridge system.

In 1953, American physicists Maurice Ewing (1906–1974) and Bruce Heezen (1924–1977) discovered that a deep canyon ran through this underwater mountain range. In some places the canyon, called the Great Global Rift came very close to land. Their findings led to an explosion in data from newly developed technology.

In 1960, Harry Hess used evidence he found, along with the work of other scientists, to propose that the movement of the continents was the result of the sea floor spreading. In 1962, he proposed a mechanism to account for Wegener's moving continents. He suggested that molten magma from beneath the Earth's crust oozed up between the plates in the Great Global Rift. This expansion pushed the plates on either side of the rift causing the Atlantic Ocean to become wider and other plates to crash into each other.

Hess proved Wegener's basic idea to be correct (one year after Wegener's death) and clarified the mechanism by which continents moved. The continents are attached to plates that shift and change shape.

In 1963, Fred Vine, Drummond Matthews, and others found that the crust surrounding the mid-ocean ridges showed alternating bands – each band magnetised with a polarity opposite to the surrounding bands. They suggested that as new sea floor crust was created in mid-ocean ridges it magnetised differently depending on the Earth's magnetic polarity at the time.

In 1966, earth scientists identified the wholesale reversal of the Earth's magnetic field 900,000 years ago. Matthews and Vine realised that the pattern of reversals matched the magnetic profile they had compiled of sea floor spreading.

This discovery, together with data from a 1964 research vessel, transformed the field of geology. It confirmed sea-floor spreading as hypothesised by Hess, and thus 'continental drift', originally proposed by Alfred Wegener back in 1912. It convinced many that plate tectonics was the best theory to unify nearly all the previously accumulated, but disjointed geological data.

Plate boundaries

There are three types of plate boundaries found at the edge of the plates:

- divergent
- convergent
- transform.

A **divergent boundary or spreading centre** occurs where two plates are moving away from each other. As the two plates part, mid-ocean ridges are created as magma wells up through the cracks and cools to form new crust. As the plates move, the ocean basin expands and a ridge system is created. Divergent boundaries are responsible for the motion driving the plates.

A **convergent boundary or subduction zone** is where one plate is riding over the top of another forcing the other into the mantle. This occurs where denser oceanic crust goes under less dense continental crust. All old crust is being destroyed as new crust is formed at spreading centres. Subduction zones are the location of very strong earthquakes and volcanic activity. The 'Ring of Fire' around the margins of the Pacific Ocean is due to the subduction zones found at the edges of the Pacific plate.

When there is a convergent boundary between two continental plates subduction cannot occur. Instead the plates plough into each other and a high mountain range is created. This is a special type of convergent boundary called a 'collisional boundary'. The Himalayas in India are the result of the Indo-Australian and the Eurasian plates colliding head on.

A **transform or conservative boundary** is one where two plates slide past each other. At this boundary plate, material is neither created nor destroyed. The San Andreas fault in California is a transform boundary where the North American and Pacific plates are moving past each other. Earthquakes occur because of the accumulation, then release of strain as the plates slide past each other.

Monitoring tectonic hazards

It is not possible to prevent earthquakes or volcanic eruptions but monitoring, prediction and management can minimise damage and loss of life.

Geoscience centres around the world work together to monitor tectonic activity. Thermal imaging techniques and satellite cameras monitor heat around a volcano.

Chemical sensors are used to detect sulphur levels. Seismometers are used to detect earthquakes. Laser beams are used to detect plate movement.

Emergency management plans and evacuation drills are developed and practised.

Earthquake-proof buildings are being constructed.

Liquefaction

Liquefaction happens when an earthquake shakes up water sitting in loosely packed sediment about 10–20 m below the ground. It occurs where the ground is made of loosely packed sediment with lots of water sitting in the pores separating individual sediment grains. It does not occur in areas where there is solid rock.

When the ground shakes the sediment grains get closely packed together and squeeze the water. As the water pressure builds up the grains become separated and act more like a liquid than a solid. The water pressure can force muddy liquid out of the ground, releasing the pressure but making the ground unstable so buildings will sink.

The closer the area is to the epicentre of an earthquake or the greater the magnitude of the quake the more liquefaction is likely to occur.

An example is seen in the Christchurch earthquakes because Christchurch is built on an alluvial plain.