

3.0 Landforms provide evidence of change

3.1 Continental Drift

Continents On The Move

Alfred Wegener collected evidence to explain the various shapes of the continents and how they were all together at one time. Along with the fossils, climate similarities, and the interlocking shapes of the continents, Wegener concluded that the continents were joined together as one supercontinent – **PANGAEA**. His explanation is called the **Theory of Continental Drift**.

Pangaea: The supercontinent 200 million years ago



The land masses after 65 million years of drift



The continents today and 50 million years from now



Biological Evidence

- fossil evidence was found on different continents, like Mesosaurus, Kannemeyrid, Lystrosaurus and Glossopteris.

Evidence from Rocks

Mountain ranges were also compared:

- the Appalachian in North America and the range in Britain and Norway were made of the same kind and age of rock
- Trilobites in the Himalayas suggested that India was once part of Antarctica, which broke off and collided with Eurasia, putting the fossils of trilobites, from the bottom of the sea, high into the Himalayas.

Geological Evidence of Climate

- coal provided more evidence, because in order for it to form, a rich tropical plant environment must have been present - coal is found in moderate to cold climates
- evidence of even greater climatic changes were found in places likely covered by glaciers (these places are now far too warm to support the presence of glaciers), this suggested that the continents may have once been part of the south pole.

Response to Wegener

After his findings were published, in a book called **The Origin of the Continents and Oceans**, Wegener's ideas were rejected. The scientific community did not agree with his assumptions and explanation that the moon might be responsible for the movement of the continents. After his death, advances in new technology and the work of a Canadian Scientist led to a new theory that explained Wegener's observations.



3.2 Plate Tectonics

Developing A New Theory

A unifying theory is one which explains several different natural events and landforms (volcanoes, earthquakes and mountains). Advances in New Technology helped explain Wegener's observations;

- *sonar* (sound wave technology) identified the **Mid-Atlantic Ridge**.
- Igneous rock contains **magnetite**, which lines itself with the Earth's magnetic field, as the rock hardens on the surface, the mineral particles maintain their alignment with the magnetic field, indicating that the reversal strips must have formed at a different time. *Magnetometers* (electronic instruments that detect the direction and strength of a magnetic field) the magnetic field in the Atlantic sometimes pointed south, instead of north (these were called reversal strips).
- *Submersibles* are small submarines that enable divers to go deeper, protecting them from the pressure of the water
- *satellites and lasers* are used to measure incremental change (change that happens slowly) in plate movements

Interpreting the Patterns

The pattern of magnetic reversal strips along the **Mid-Atlantic Ridge** meant the sea floor was spreading, leading to the **Theory of Sea Floor Spreading**. (as new rock forms, it takes on the magnetic polarity of the Earth at the time of formation). The ocean floor is moving deep into the trenches along the continental boundaries. Confirmation of the theory of sea floor spreading was provided by the ship, Glomar Challenger, which brought drill samples up from the ocean floor (younger rock was closer to the ridge and older rock was closer to the continents). Most earthquakes and volcanoes are concentrated in specific areas, and there are places where no earthquakes or volcanoes occur.

The Theory of Plate Tectonics

All the evidence collected indicates that the Earth's crust is broken up into plates, which are moving on the Earth's mantle. The new theory is called the **Theory of Plate Tectonics**. Plates pushing together are called *converging plates*, whereas plates pulling apart are called *diverging plates*.



J Tuzo Wilson (a Canadian Scientist) helped form this new theory, by suggesting the plates slide past each other. This type of movement is seen at a *transform boundary*.

Convection Currents

A convection current is the circular flow within a fluid that is caused by the rising of warmer particles and sinking of cooler particles. Scientists believe it is this action, within the mantle, which is causing the plates to move. The plates that collide, or converge have one plate above and the other below (these places are called *subduction zones*). Subduction zones occur where the convection currents, in the mantle, cool and sink.

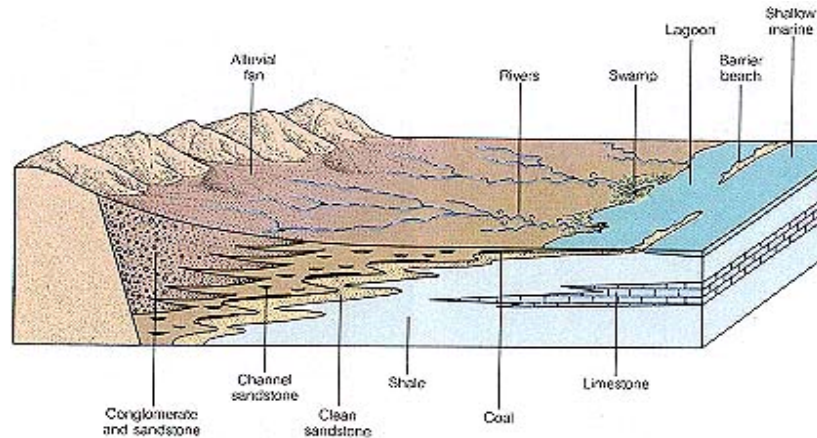
3.3 Mountain Building

What Is Mountain Building?

A mountain is part of the Earth's surface that is much higher than the land around it. A mountain range is a series of mountains (*Cordillera* is Spanish for mountain range).. The *Rocky Mountains* extend from the Yukon in the far North, between British Columbia and Alberta, through the western United States and into Mexico – making it one of the longest mountain ranges in the world. Mountain building takes many years. Most mountains are large areas that have uplifted due to the movement (converging, diverging or sliding) or heating of tectonic plates, where the build up of heat and pressure can cause folding and faulting.

Building The Mountains: An Alberta Story

600 million years ago Alberta had a tropical climate, and it was bordered by a shallow sea (where British Columbia is now). The shallow sea was constantly being filled with sediments. The layers were 10-15kms thick.



After more than a billion years of sediment buildup the collision of two plates happened. The North American Plate and the Pacific Plate met. The Pacific Plate was forced down and the North American Plate rode above it. But the force and pressure of the collision cause the edge of the North American Plate to fold and break and some of the parts were pushed up and over each other, creating the Rocky Mountains. The Rocky Mountains are complex mountains.

The Structure and Development of Fold and Fault Mountains

Sedimentary rock under slow, gradual pressure can fold (bend like plastic because they are made soft by the heat) or break - and can be changed to metamorphic rock in the process. The upward, or top part of folded rock is called *anticline*, the bottom is called *syncline*. Rock that is too brittle to fold under heat and pressure, will break, called *thrust faulting*. When older rock ends up on top of younger rock as a result of thrust faulting, the result is the formation of *fault block mountains*. Movement of rock along a fault can be vertical or horizontal and can be traced by the location of the 'basement rock' on both sides of the fault.

Where Does The Folding Happen?

Heat and pressure soften and force rocks to fold and break. Mountains that are jagged at the top are 'young' mountains, while those that are more rounded (due to erosion and weathering) are 'old' mountains. The Himalayas are the youngest mountain range with the highest mountains (and still growing) mountains, such as Mount Everest. It rises about 1cm each year.

Mountains With Faults

Subduction of the Juan de Fuca plate (off the west coast of North America) has caused folding, faulting and uplifting, and magma has created volcanoes. The place where the crack or break occurs is called the fault and is often below the surface of the Earth. Some faults are visible in layered rock that has been uplifted.