GZ Science Resources

Science NCEA L1

Easy to read Version

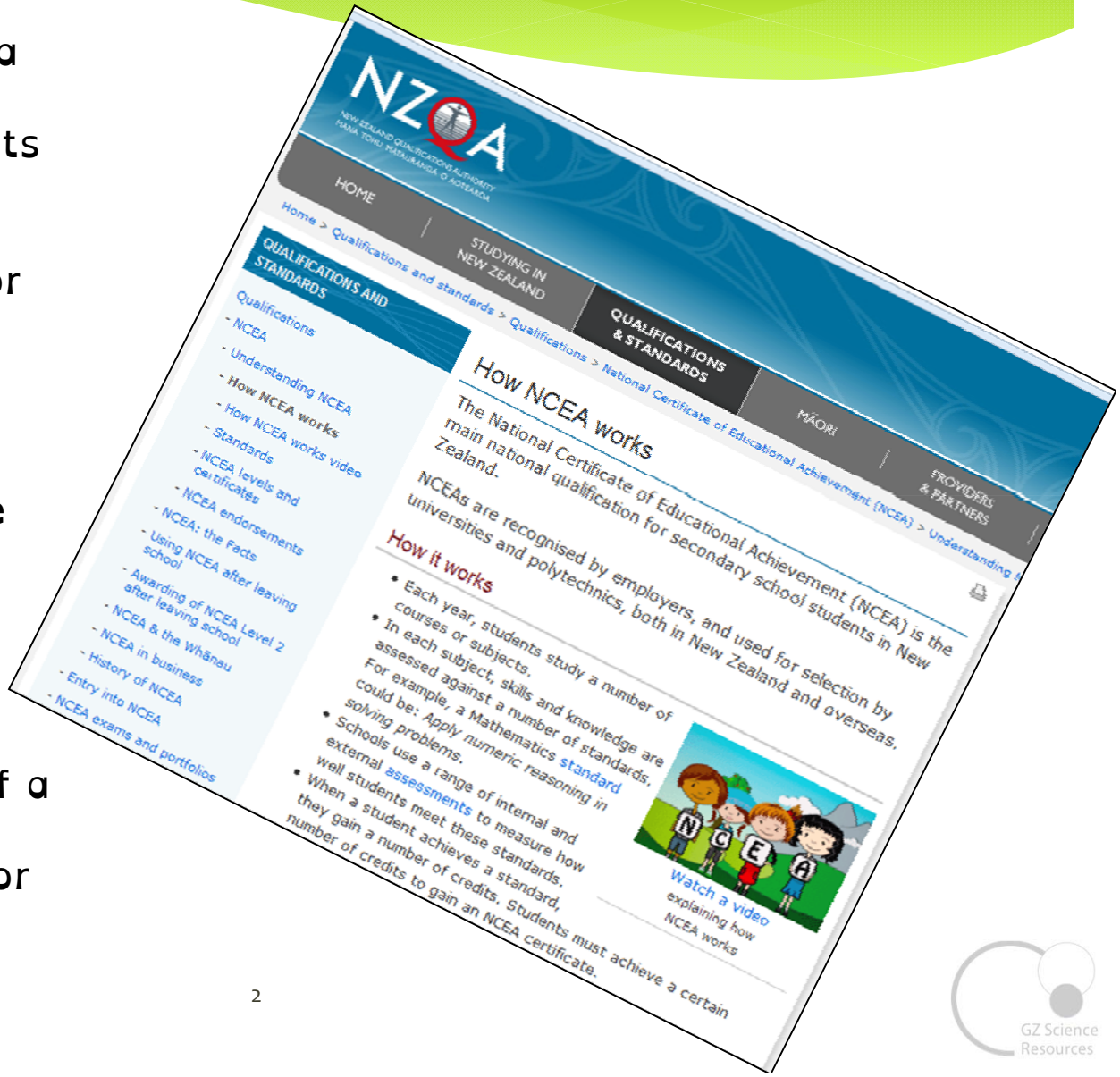
1.13 Surface Features

What is a NCEA Achievement Standard?

When a student achieves a standard, they gain a number of credits. Students must achieve a certain number of credits to gain an NCEA certificate (80 for Level 1)

The standard you will be assessed on is called **Science 1.13 Demonstrate understanding of the formation of surface features in New Zealand.**

It will be internally (in Class) assessed as part of a **research project** and will count towards **4 credits** for your Level 1 NCEA



What are the main steps required in this Internal Assessment?

1. You will research the surface features of two areas: **White Island** and **Waitomo Caves** and present a report

The research will involve learning in class for **TWO** weeks prior to presenting the report AND at the same time complete home based individual research from the Internet, science publications, textbooks, and geology books.

2. Your presented report will be completed in the **third** week under individual test conditions in class over 3 periods. You will be allowed to bring in all researched material to help you complete your report.

Your report will :
>provide information about the **surface features** of their areas
>explain in-depth how **two** surface features of the areas were formed
>explain in-depth **geological processes** for each surface feature by the use of reasoned explanations and in-depth linking of the processes to the final surface feature observed today
>support their report with visual representations and data where relevant.

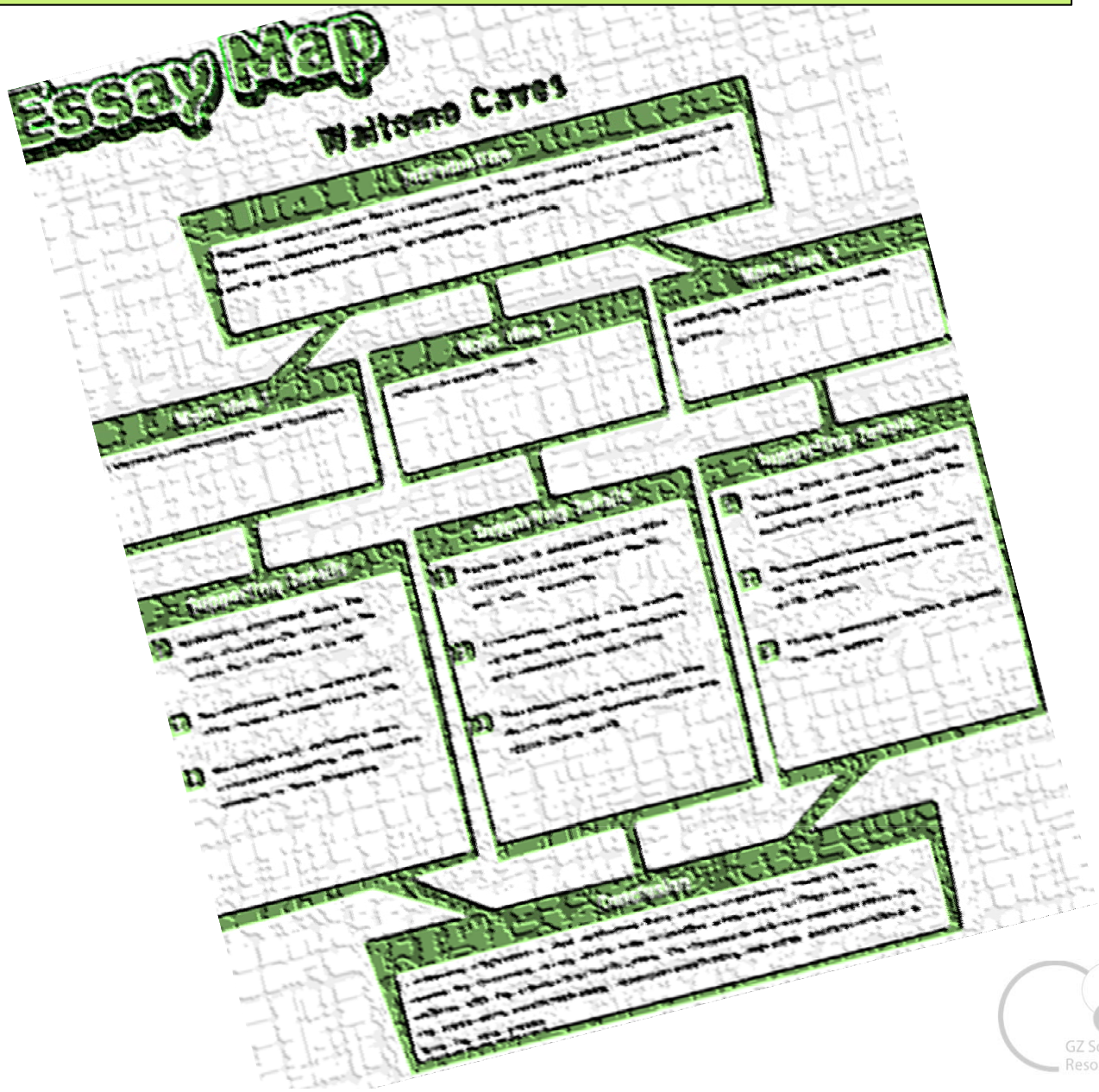
Planning your report

Start your report with an **introduction** outlining the surface features selected for the area and then link the surface feature to the external and/or internal processes that formed them.

For each area decide on important **main ideas**

Back up the main ideas with **supporting details**

Draw a **conclusion** that summarises your main points.



Researching your report

Once you have decided on the main points of your report you will need to **gather** and **sort** information from various sources.

Gathering

The internet is a great place to get information, but it should never be the only place to get information. Back up internet information with books on the subject. In addition, use as many primary sources as possible.

Primary sources can also include photographs, audio recordings and videos.

All sources need to be referenced with title/website address, Author/webpage author and date.

Sorting

Information needs to be put in some sort of order. Sort information into categories and start to get rid of the information that you won't use. Also remove repeated information. This is especially true of Internet resources where there may be a lot of cut and pasting.

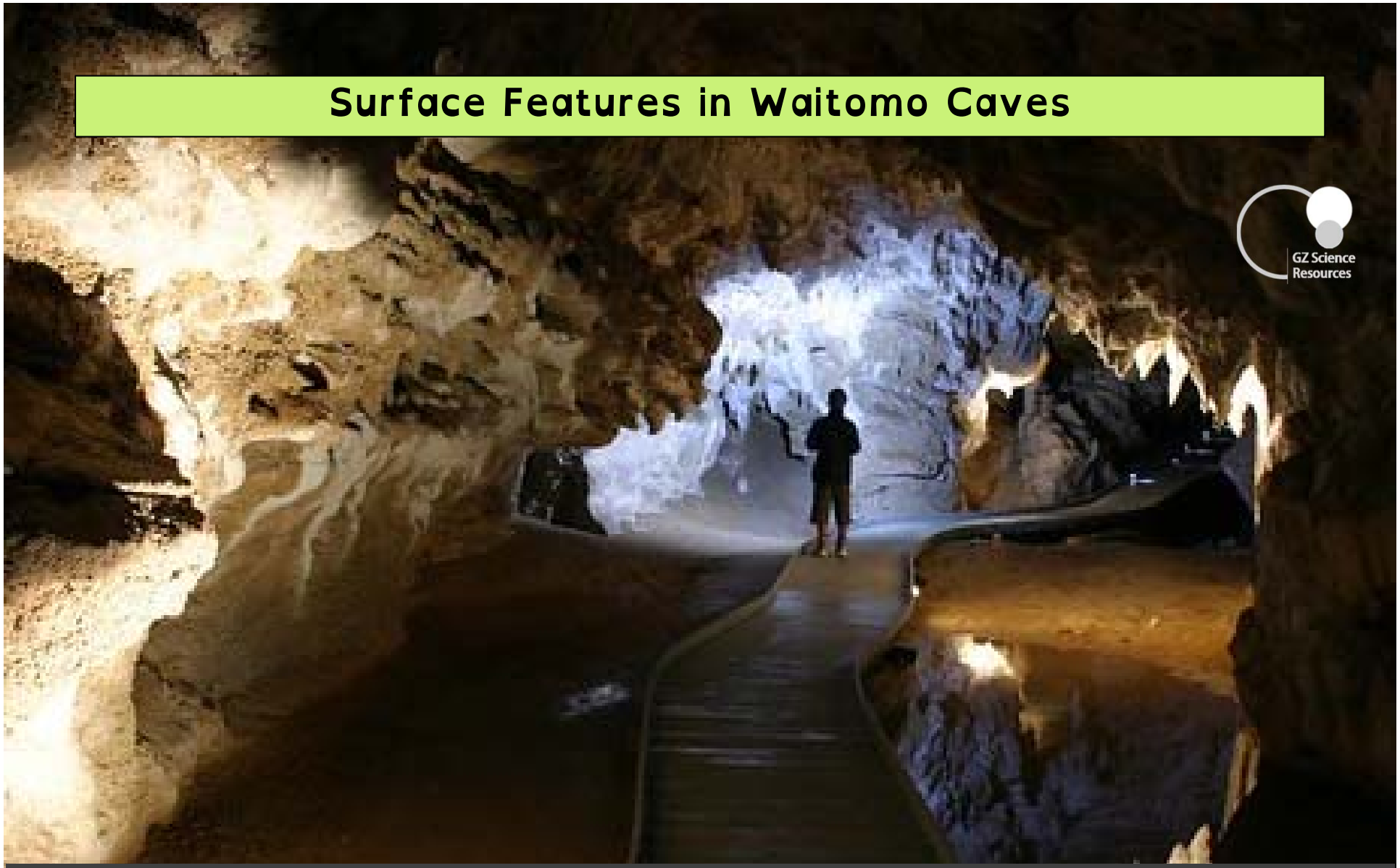
Keep paper copies, clearly referenced to bring in with you to start your report.

Prepare a draft copy of your report and check that you have all the information required to cover every main idea.

Surface Features

Surface features may include one or more local and/or national features such as:
volcanoes and/or volcanic features as found on the White Island and the **limestone formations such as caves and sink holes** as found in the Waitomo Caves area (as seen above)

Surface Features in Waitomo Caves



Waitomo Caves are made from limestone rock. The cave system is a surface feature that has been created by both internal processes of plate tectonics and rock formation as well as the external processes of weathering and erosion.

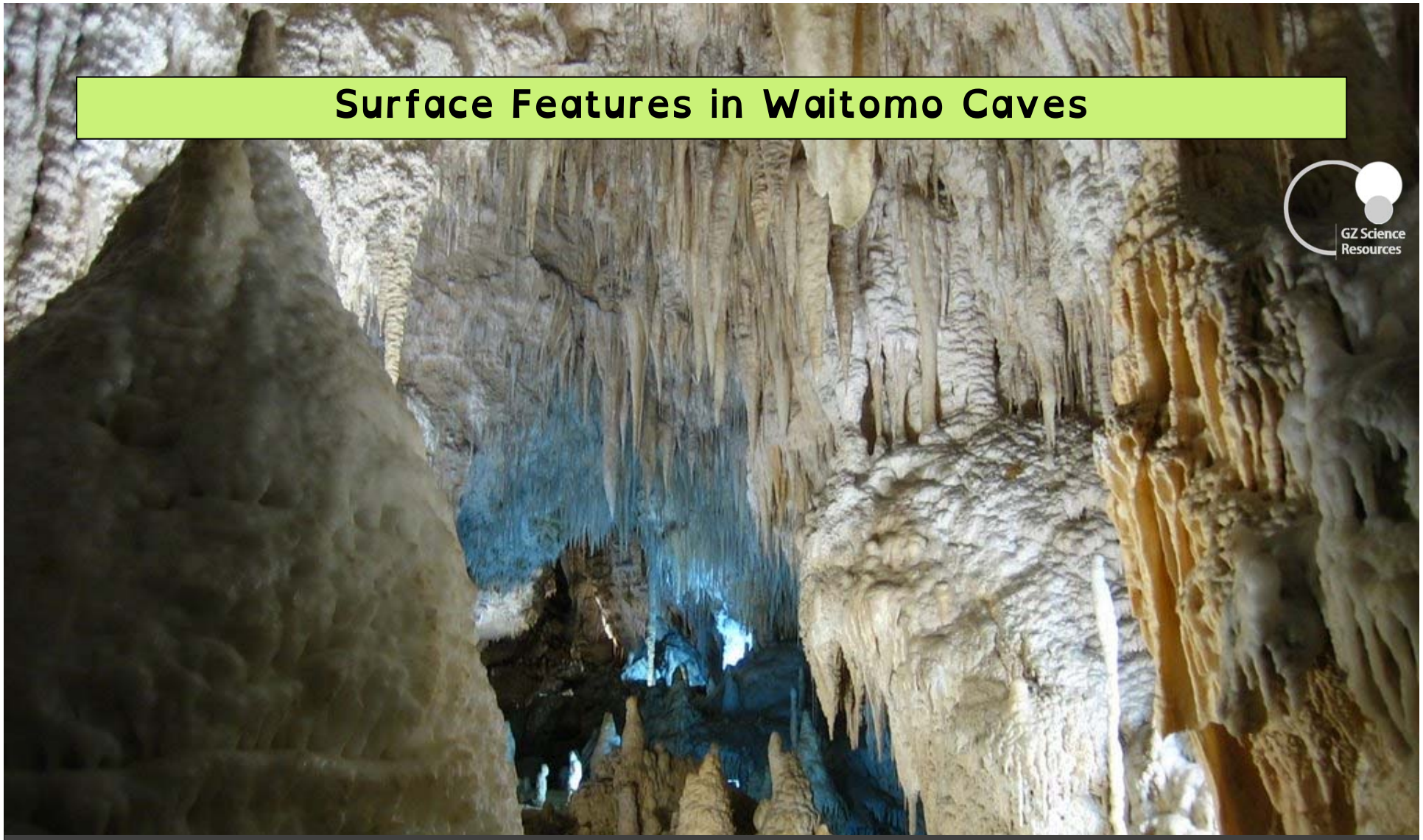
Surface Features in Waitomo Caves

The limestone rock that the caves are made from have been formed through a sedimentation process. Sediments originated from the shells of marine life falling to the ocean floor millions of years ago. The sediments were covered with other layers of materials over time. The buried shell sediments were compacted together with heat and pressure to form limestone.

Surface Features in Waitomo Caves

The limestone rock created on the ocean floor has been uplifted due to tectonic forces. Plates that sit underneath the New Zealand land mass are the Pacific and Indo-Australian plates. Convection currents in the mantle caused the two plates to move past and converge into each other. The limestone rock formation that sits on the Indo Australian plate was raised due to uplift.

Surface Features in Waitomo Caves



Weathering and erosion have formed the cave systems. The top layers above the uplifted limestone rock were exposed to the weathering of wind and rain. The exposed limestone was eroded by carbon dioxide dissolved in the water to form an acidic solution. Flowing waterways further enlarged the cave system.

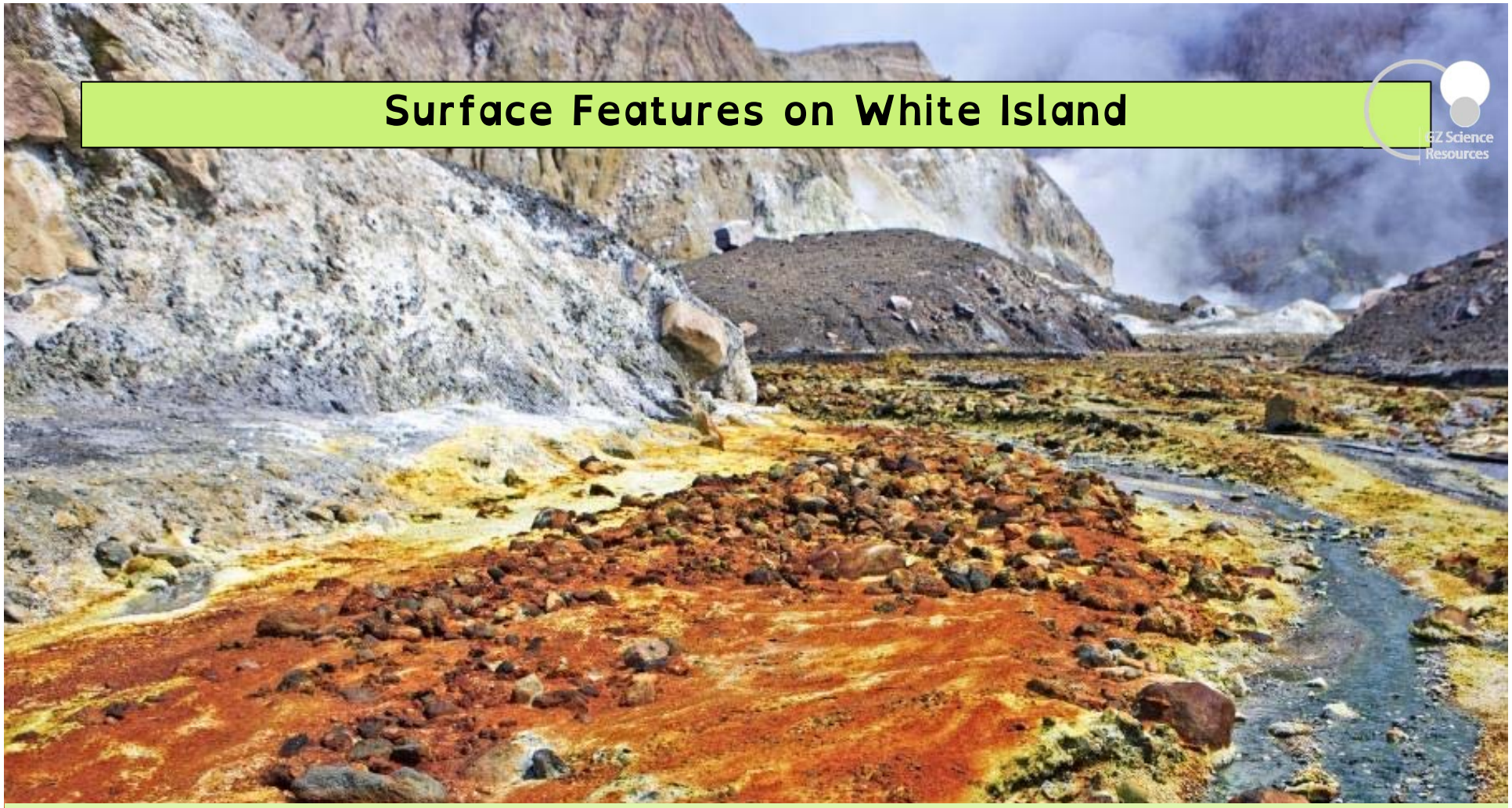
Surface Features on White Island

White Island is the summit of an active volcano situated mostly under water off the coast of Whakatane in the Bay of Plenty in New Zealand. The volcano consists mainly of Andesite Igneous rock and has a lake at its center in the crater.

Surface Features on White Island

The crater lake of White Island has a temperature of about 65ºC and fills the crater formed from one of the many Volcanic explosions.

Surface Features on White Island



White Island is one of the many Volcano hotspots that sits in the Taupō Volcanic Zone. This zone is at the front of a wedge where the Australian and Pacific tectonic plates collide. The pressure forces up magma and results in Volcanos forming during an eruption.

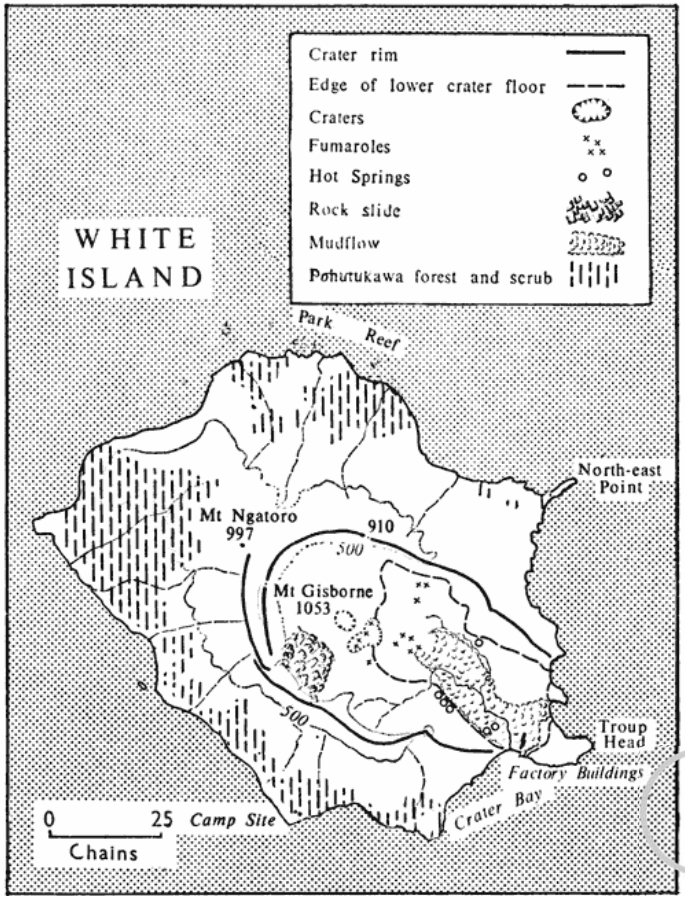
Geological Process

Each surface feature described must be linked to the various geological processes that formed them.
Geological processes are divided into **Internal Processes** and **External Processes.**

Internal Processes are processes that take place under Earth's surface and include:

>The formation of Sedimentary Limestone rock and its eventual uplift due to Tectonic forces.
>The formation of volcanoes due to collisions between the Pacific Plate and the Australian Plate

External processes are processes that occur on the surface of the Earth, such as erosion and weathering caused by wind, ice, water, animal and plant action, human action, and changes in sea levels.



The Earth is made from exploding stars

Our solar system was created around **4.7 billion years ago** when a huge cloud of stardust (debris from older exploded stars) contracted under gravity.

The mass began to spin as it contracted – much like a figure skater – and formed a disc with a bulge at the center.

The bulge developed into our Sun, which contains 99% of the solar systems mass.

The sun got hotter as the material **compressed** together, until finally it was hot enough for a nuclear reaction to start.

The Earth is made from exploding stars

The remaining material was flung out along a **single plane** and material lumped together at various distances from the sun to form planets including **Earth.**

The gravity created by the planets mass causes the planets to become spheres.

The gravity of the sun causes the planets to orbit the sun rather than traveling away.

The Moon was created was a smaller planet smashed into Earth and the fragments formed into a circular orbiting satellite.

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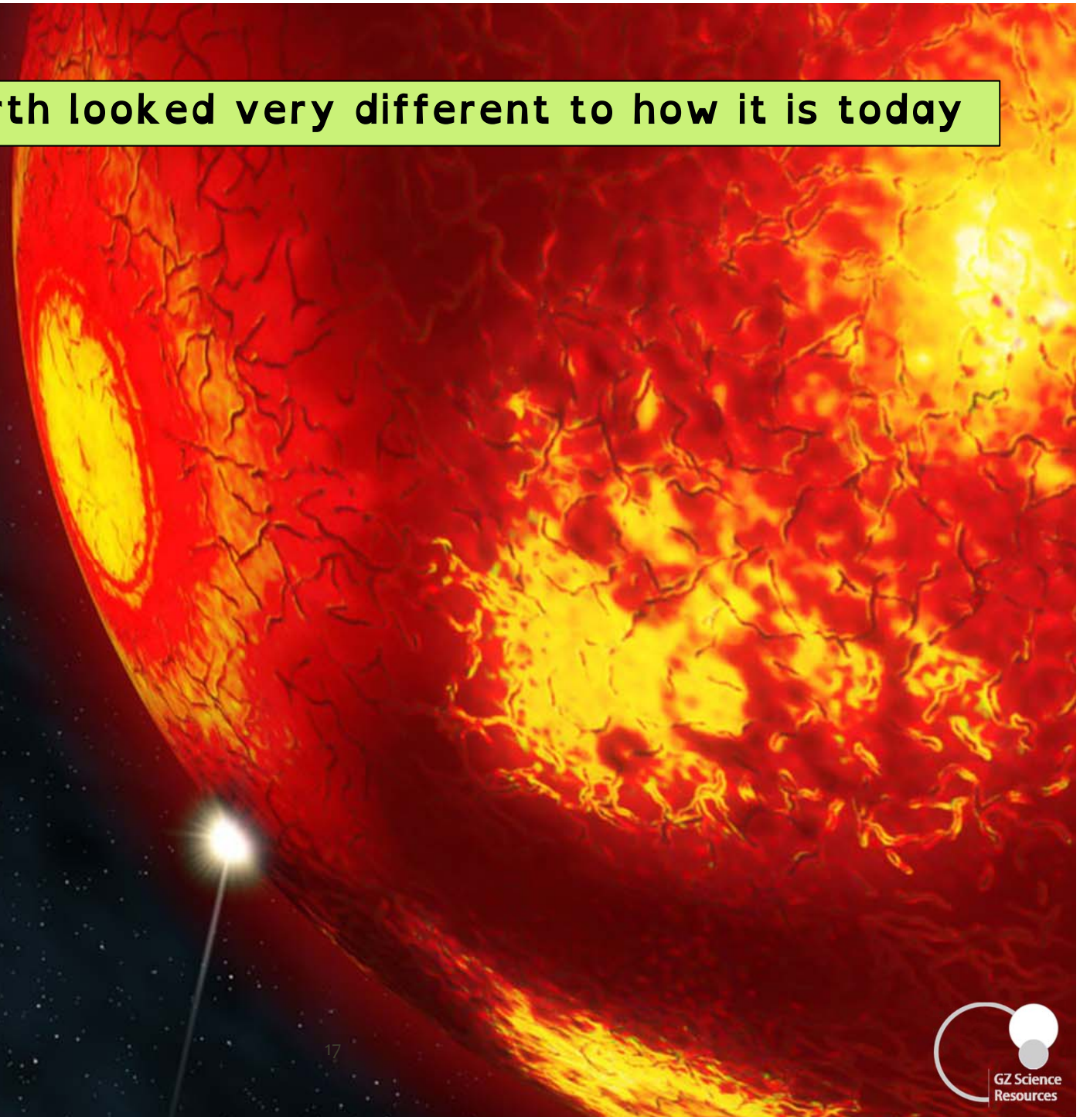
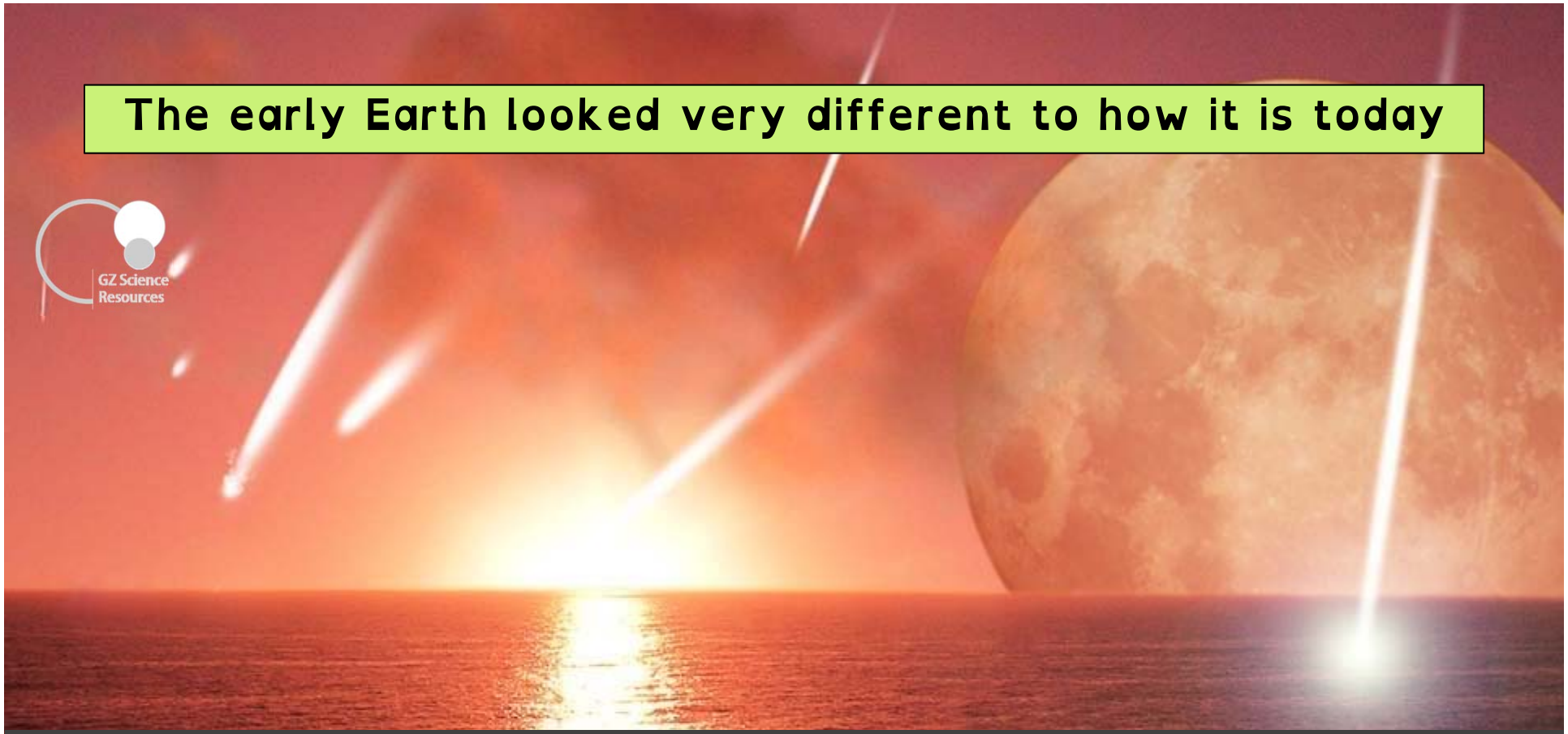
The early Earth looked very different to how it is today

The Earth, formed over 4 billion years ago and the heavier matter such as iron sank to the centre and lighter matter such as silicon and carbon rose toward the surface. The planet became layered, and the layers of the core and mantle were formed.

Much of the matter that went toward the centre contained radioactive material, an important source of Earth's internal heat.

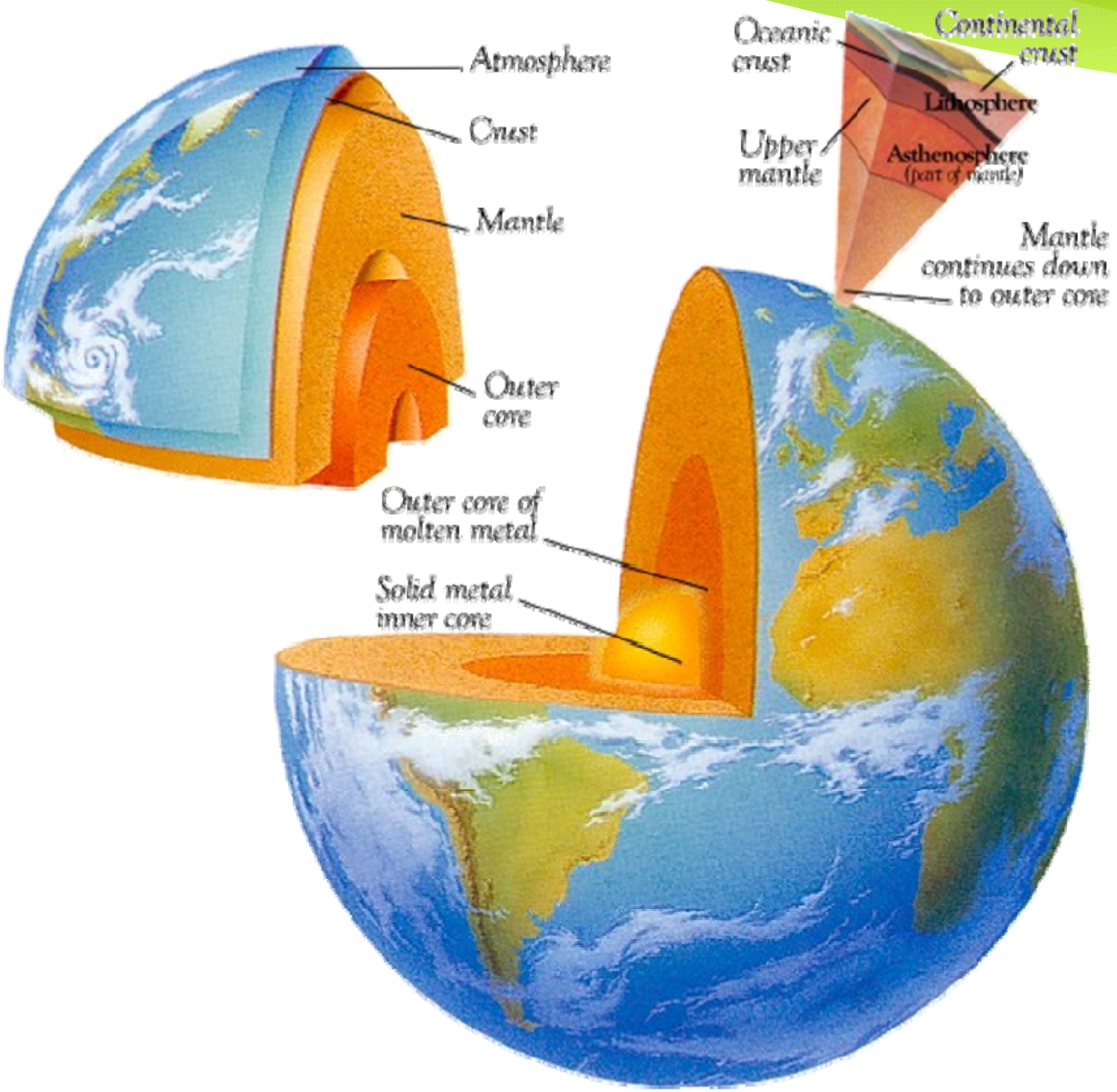




Shortly after the Earth and the Moon were formed they underwent a period when they were bombarded by meteorites, the rocky remains left over from the formation of the solar system. Huge impact craters are still visible on the Moon's surface, which is unchanged. Earth's craters, however, were long ago erased by weathering, erosion, and mountain building.

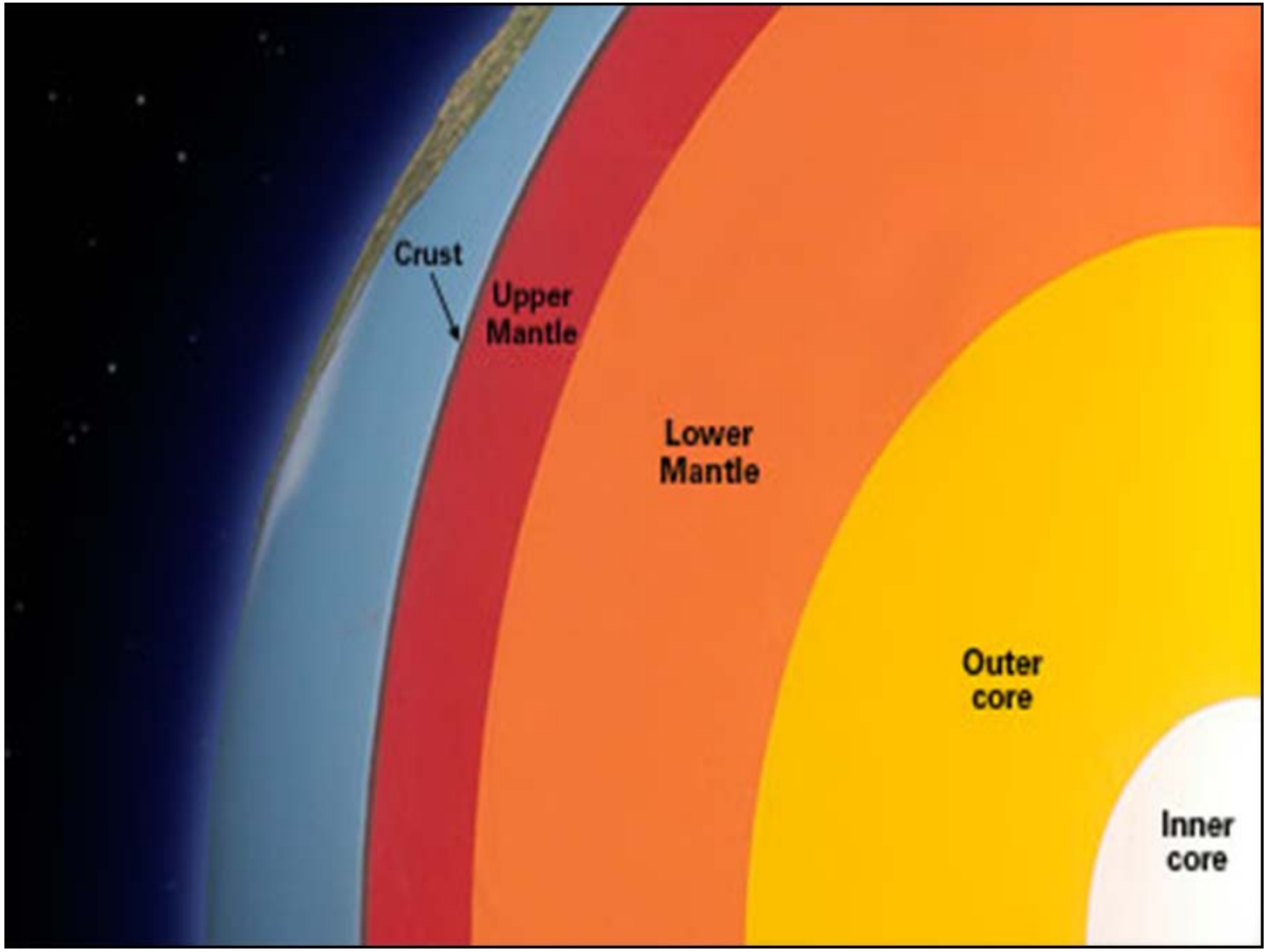
Huge amounts of energy released from the meteorite impacts created extremely high temperatures on Earth that melted the outer part of the planet and created the crust.

The Earth is made up of different layers



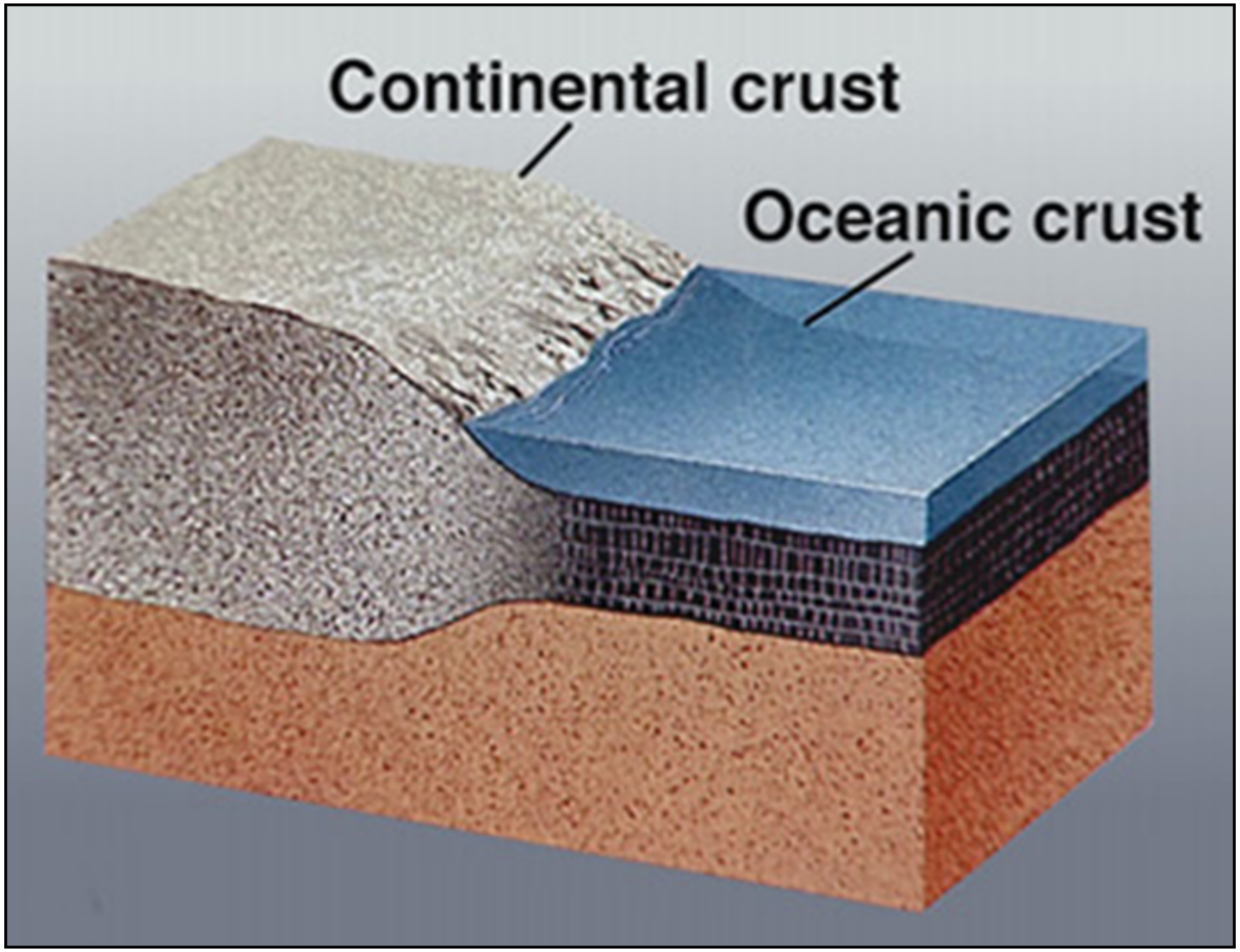
The Earth is made up of different layers , each one of them composed of different materials. In the centre of the earth is the heaviest material mainly composed of Iron. Further out is dense heavy rock and near the surface is lighter rock.

Earths composition and structure



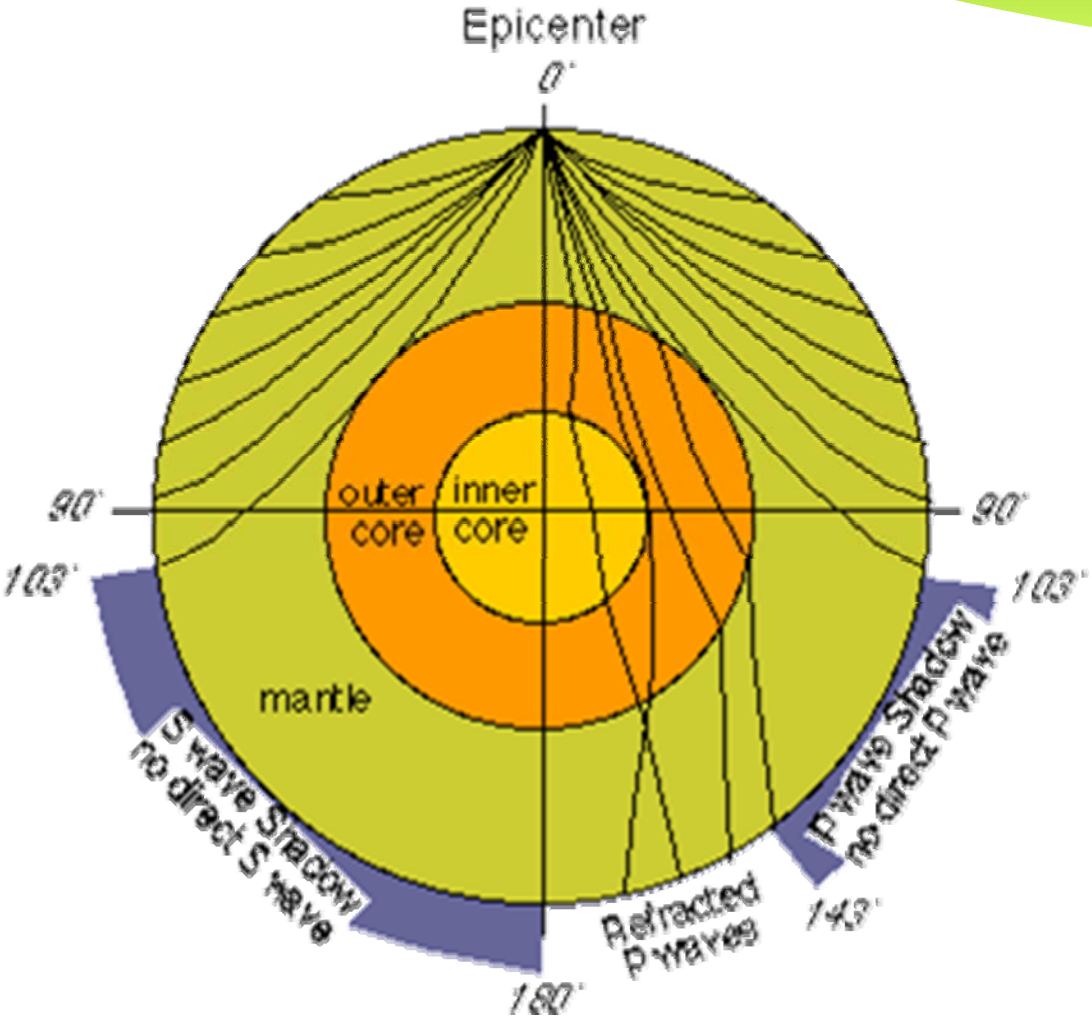
The thin layer of solid rock which covers the Earth is called the **crust.** Under this is the **mantle.**
The middle of this is molten - so the upper mantle and crust float on this.
The inner layer is the **core**, which is a solid core surrounded by molten rock.

Earths composition and structure



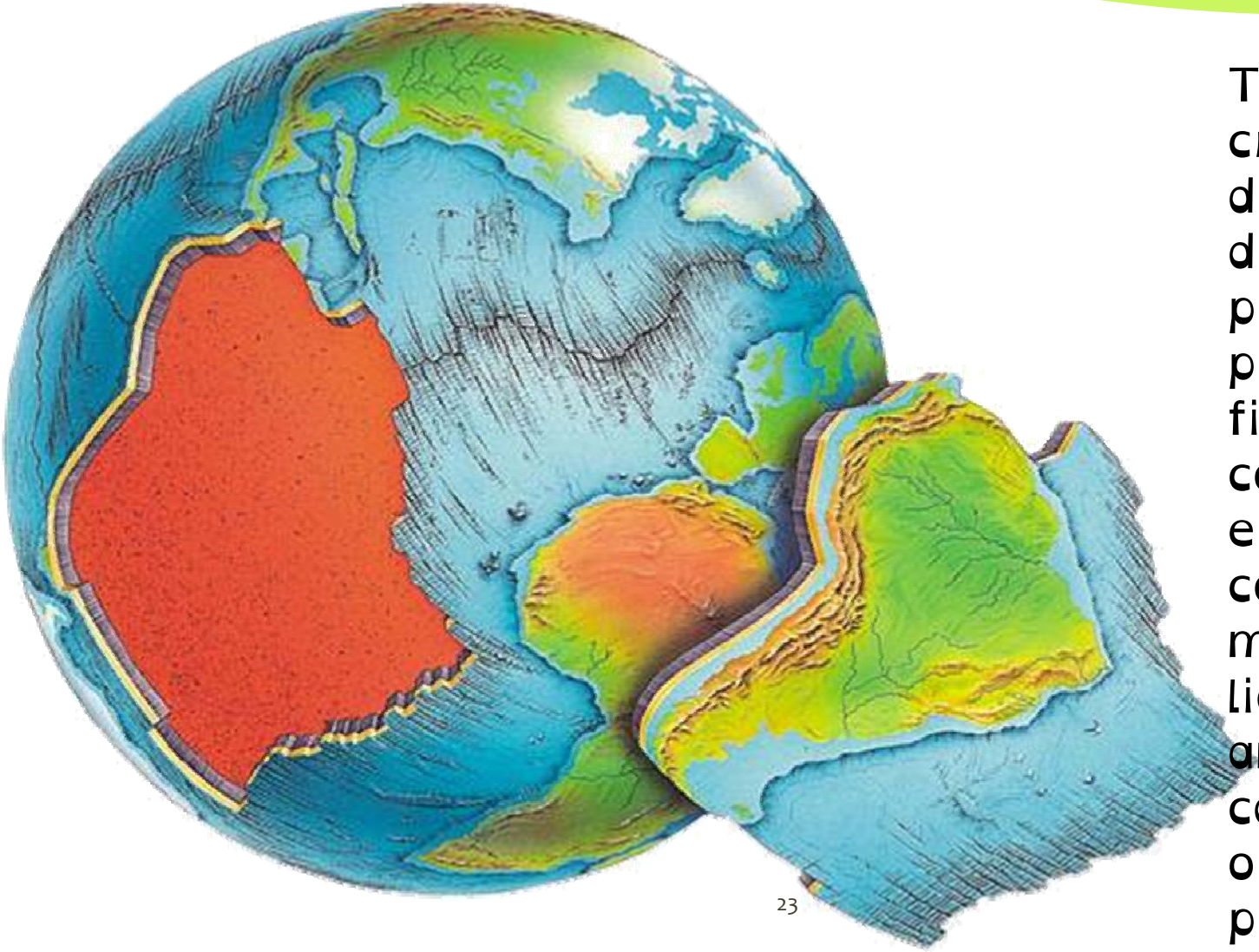
The crust is made up of the thick continental crust that forms the land and the much thinner oceanic crust that makes up ocean floors.

Earths composition and structure



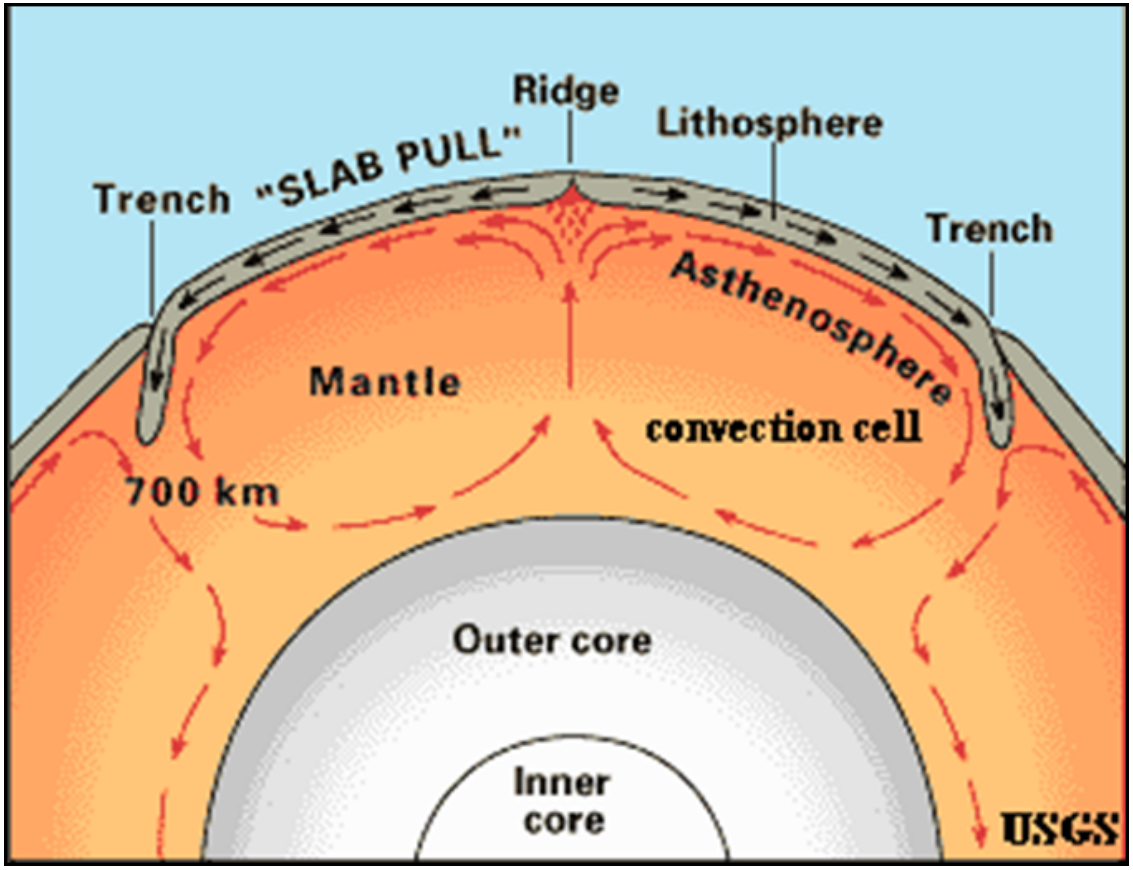
When earthquakes occur they send waves through the earth. Different types of material with different temperatures will cause the waves to bend in different ways. Seismologists (earthquake scientists) record where in the world the waves come out and use that information to work out the size of layers, what the temperature of them is and what they are made out of

Earths crust is divided into large plate that can move in relation to each other



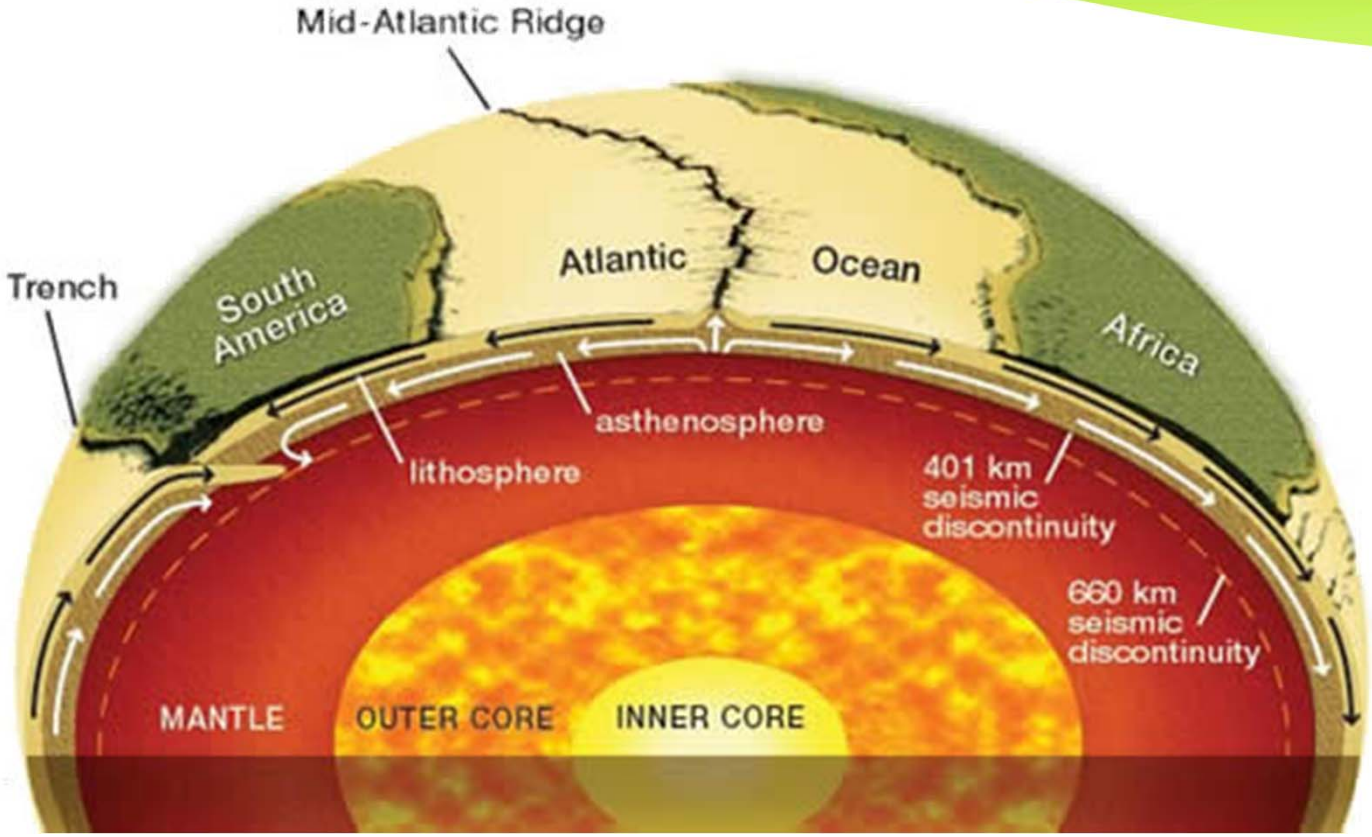
The earth's crust is divided into different sized pieces called plates. They fit together to cover the earth. The continents are made of lighter rock and are carried along on top of the plates.

Earths heat drives plate movement: Plate Tectonics Theory



The plates float on hot, semi molten magma. Deep inside Earths core nuclear reactions release huge amounts of heat energy. This heat is the main source of energy for moving the gigantic plates. This heat causes the magma in the lower mantle rock to expand and become less dense.
This magma rises in convection currents.
When the magma currents get near the crust they are pushed sideways and travel in different directions.
These immensely powerful currents slowly float the huge tectonic plates across the planets surface.

Earths heat drives plate movement: Plate Tectonics Theory

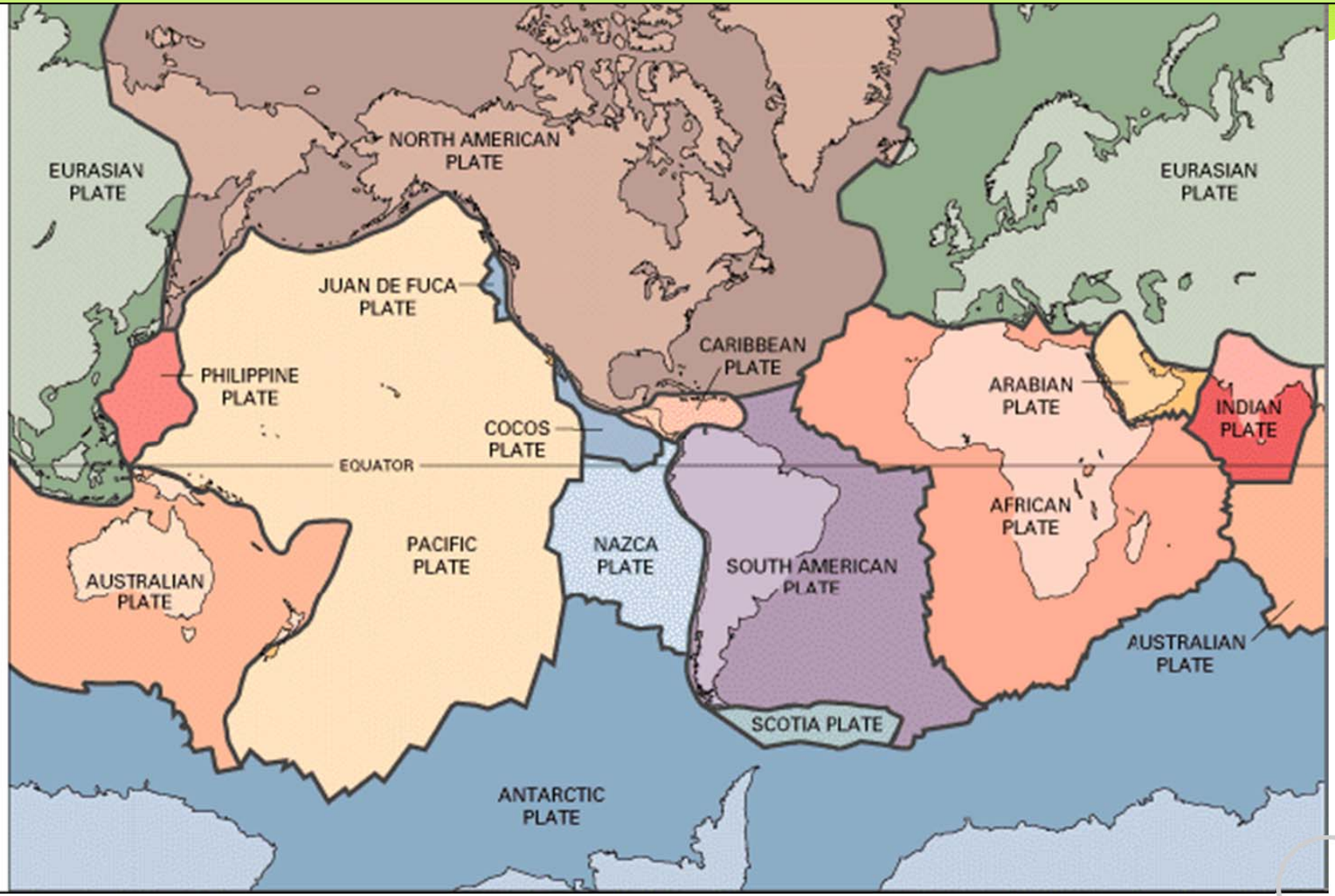


The Lithosphere, the crust and top part of the mantle, is divided into large areas called plates, which are constantly moving The plates move slowly over the asthenosphere, which is the molten layer in the mantle, about 3cm a year.

They can move towards each other, apart from each other or shift sideways Because all plates fit together, movement of one plate effects all plates around it.

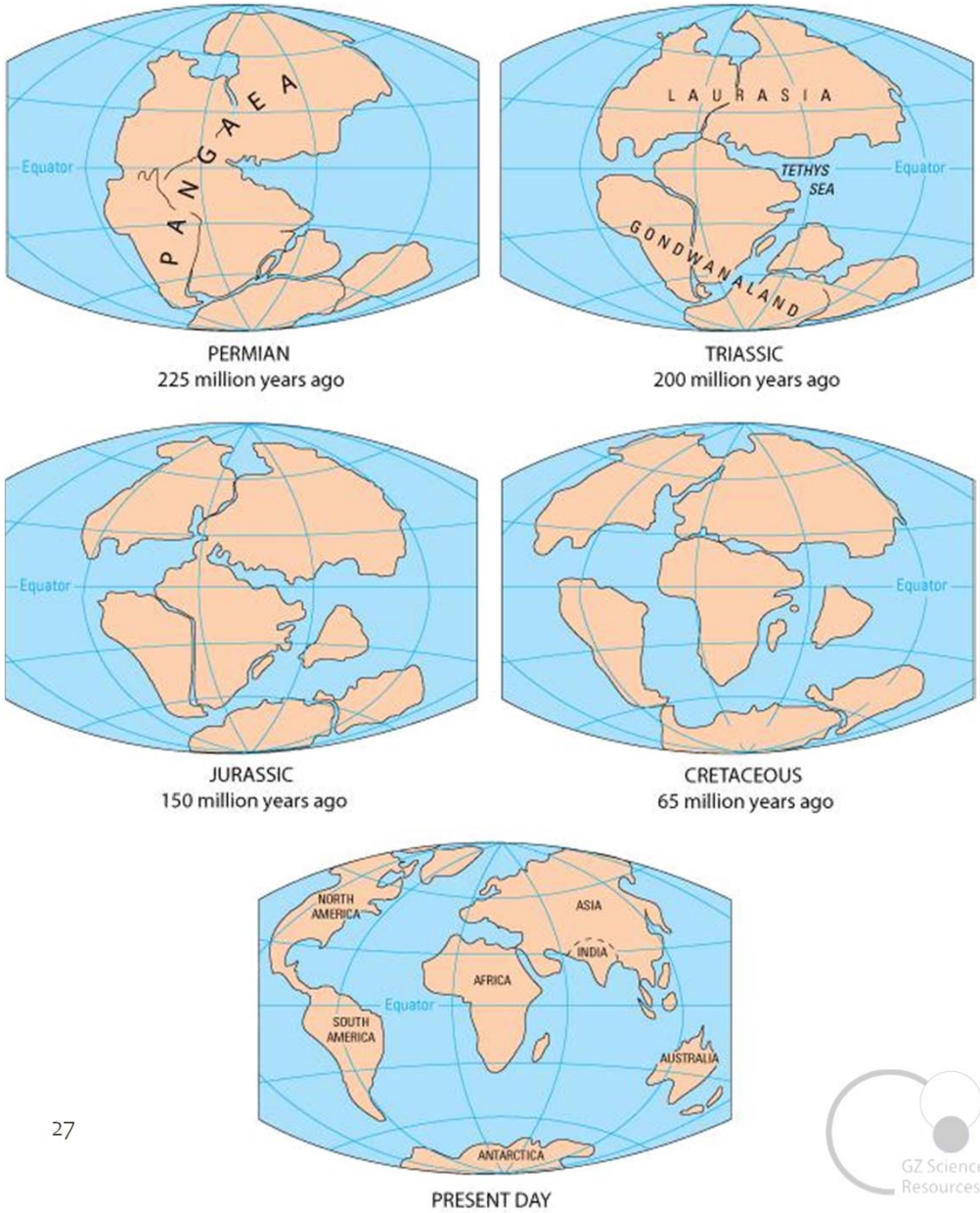
The study of plate movement is called plate tectonics and the observable effect is called continental drift.

Earths heat drives plate movement: Plate Tectonics Theory



There is evidence for continental drift

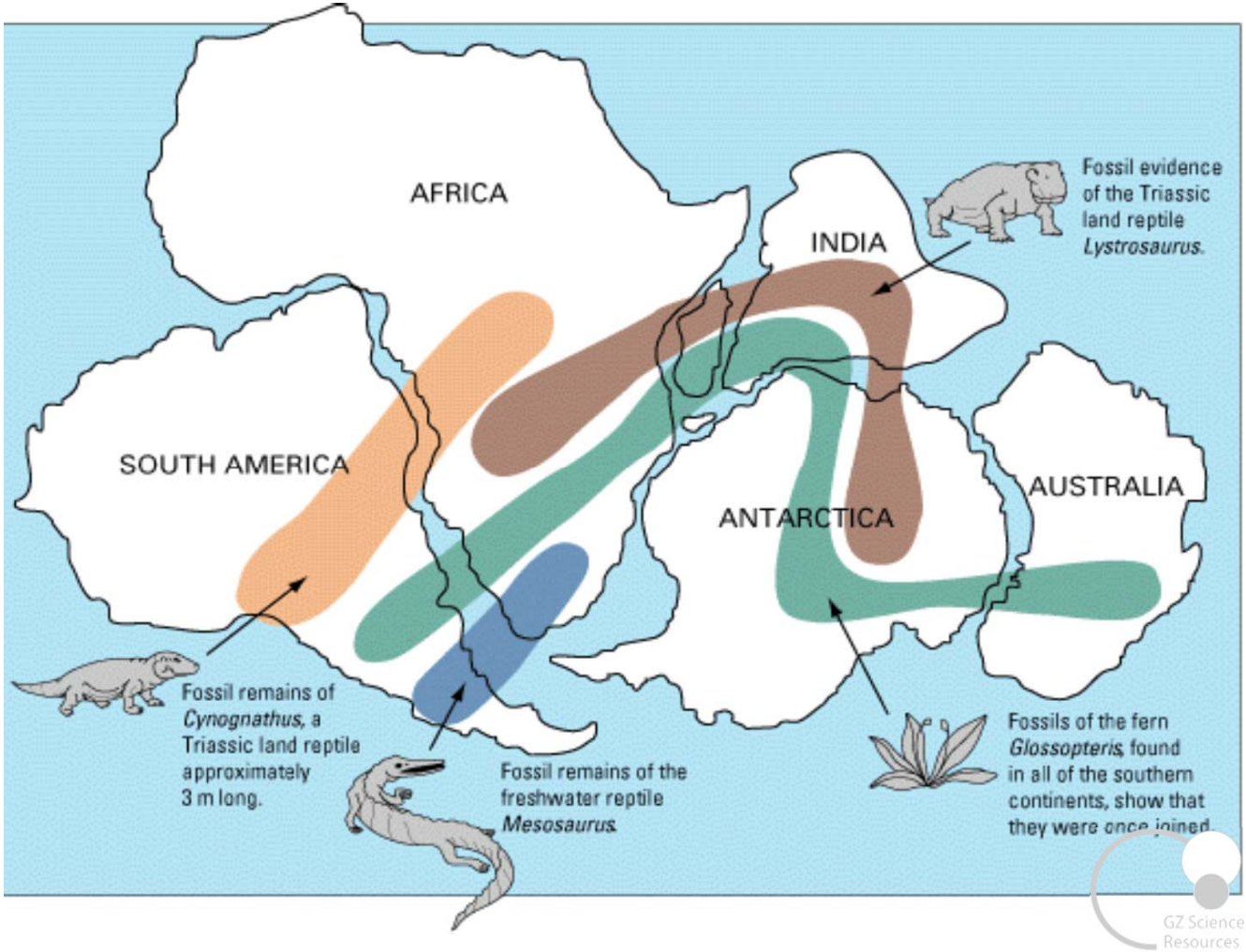
Evidence supports the conclusion that 200 million years ago, at the start of the Mesozoic era, all the continents were attached to one another in a single land mass, which has been named Pangaea.
During the Triassic, Pangaea began to break up, first into two major land masses: Laurasia in the Northern Hemisphere and Gondwana in the Southern Hemisphere.
The present continents separated at intervals throughout the remainder of the Mesozoic and through the Cenozoic, eventually reaching the positions they have today.



There is evidence for continental drift

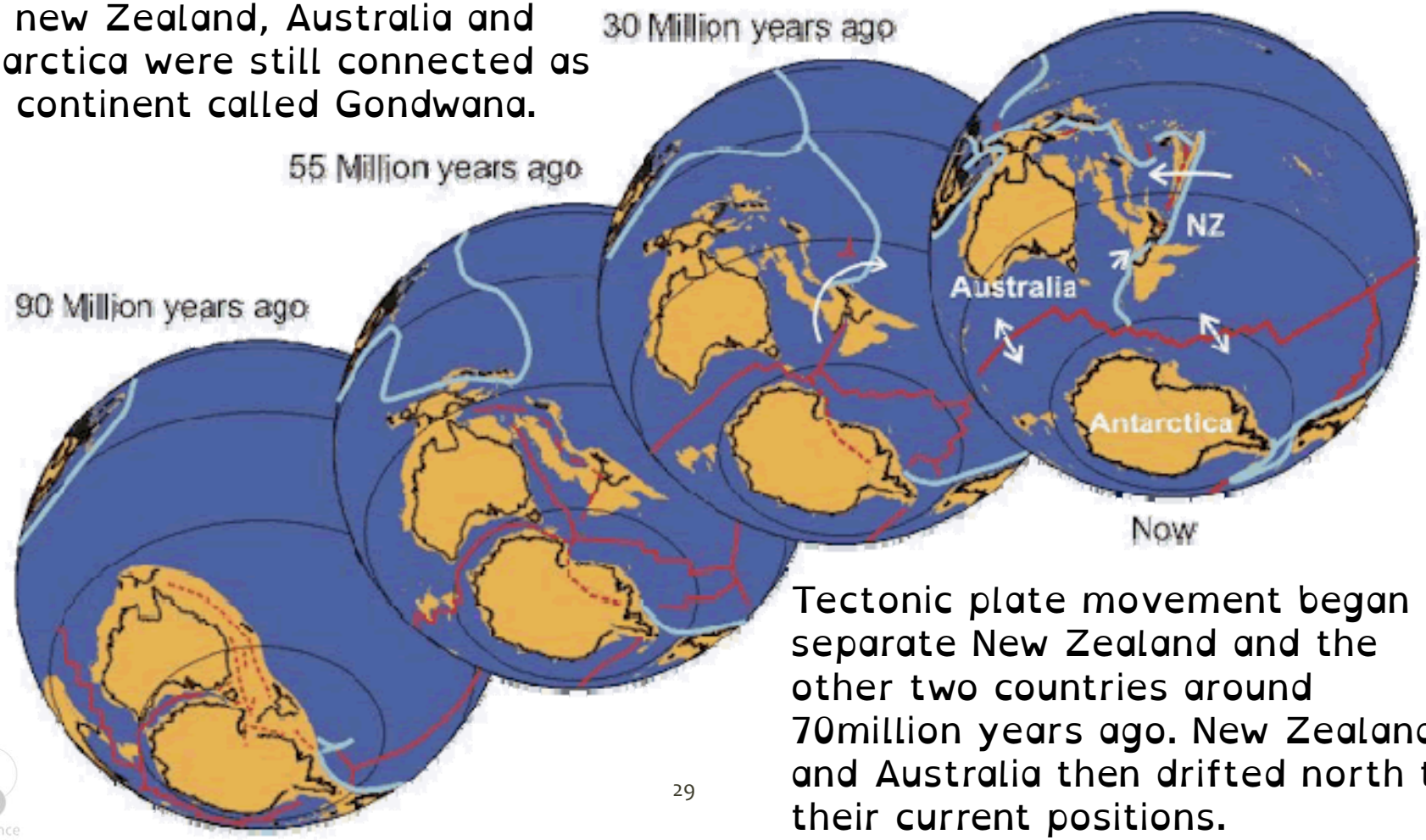
Shape of the Continents – close fit of continents
The east coast of South America and the west coast of Africa match especially at the boundaries of the continental slopes rather than the shorelines.

Geology – similar rock patterns
In both mineral content and age, the rocks on the coast of Brazil match precisely those found on the west coast of Africa.
The low mountain ranges and rock types in North America match parts of Great Britain, France, and Scandinavia.
Fossils – patterns in distribution
The same fossil reptiles found in South Africa are also found in Brazil and Argentina.



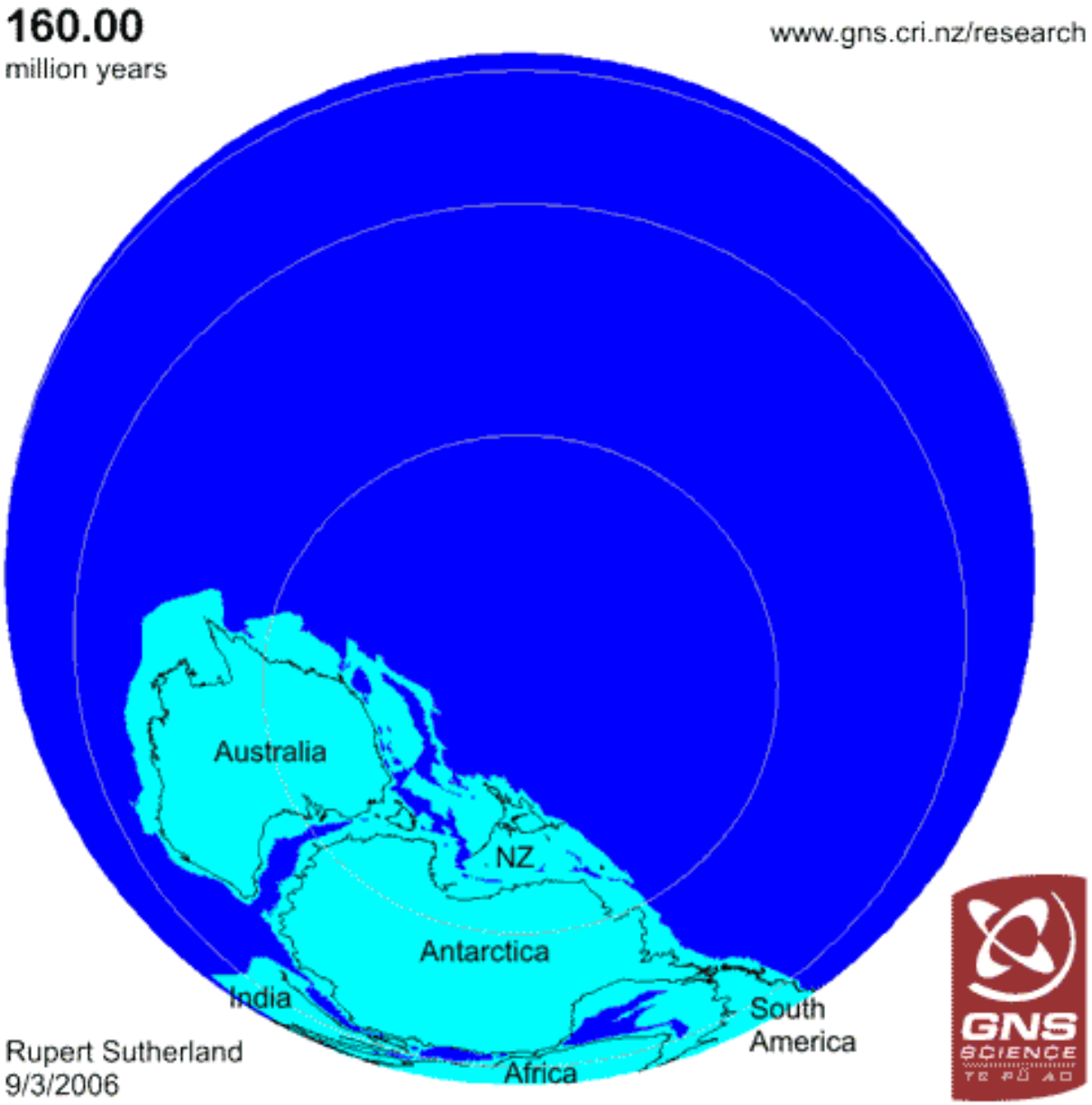
Formation of New Zealand

New Zealand was originally formed from sediments eroded from the much older land mass of Australia. Around 90million years ago new Zealand, Australia and Antarctica were still connected as one continent called Gondwana.



Tectonic plate movement began to separate New Zealand and the other two countries around 70million years ago. New Zealand and Australia then drifted north to their current positions.

Formation of New Zealand



Divergent, convergent and transverse boundaries

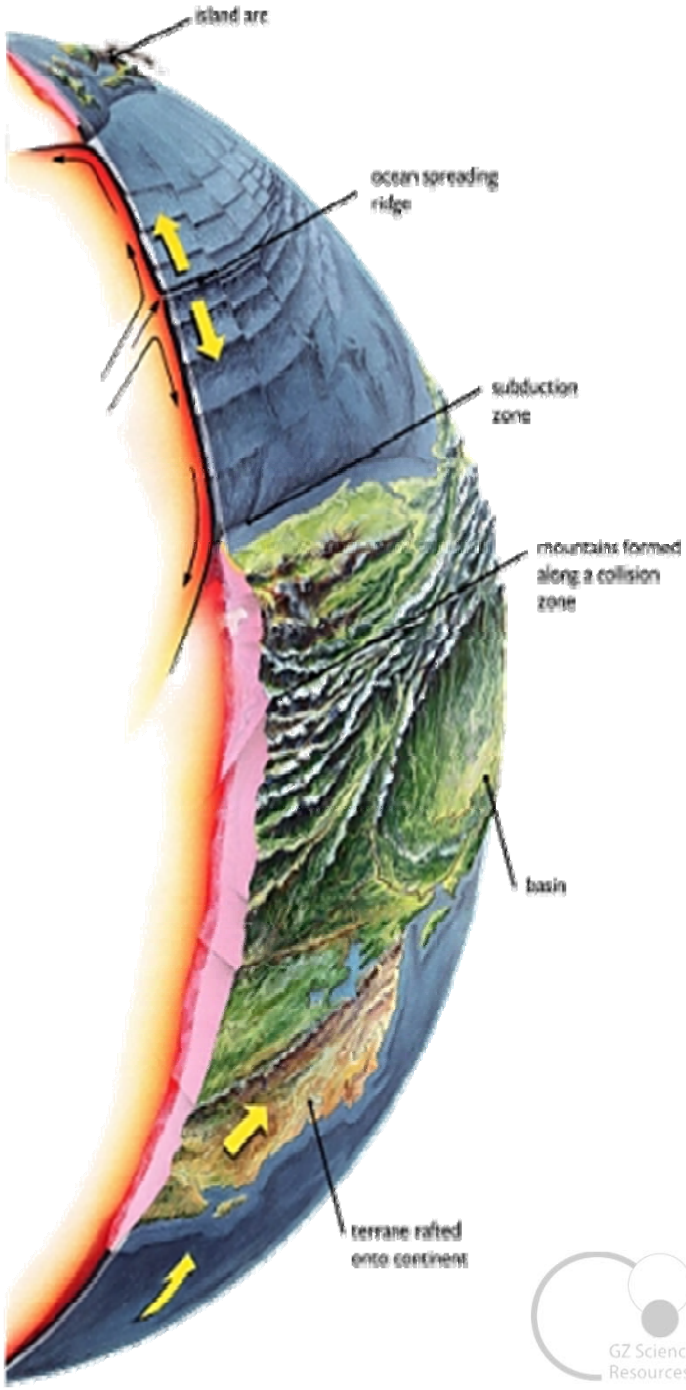
When plates move the continents sitting on top of them move as well.

Plates can either;

- Move away from each other
  – divergent boundary

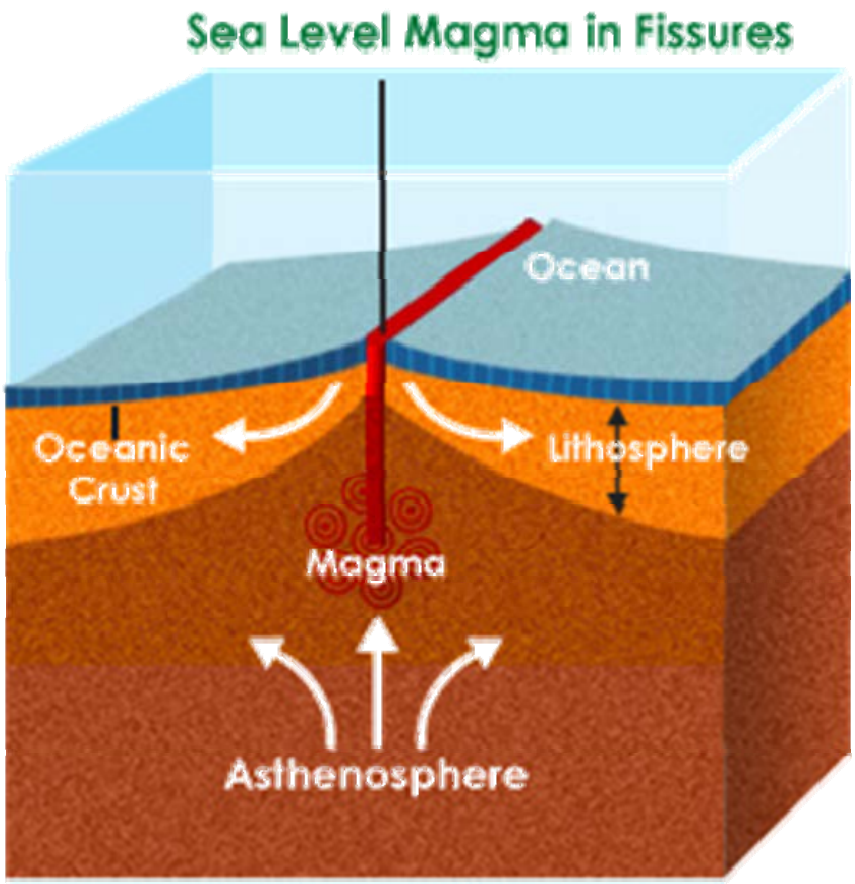
- Move towards each other
  – convergent boundary

- Move sideward pass each other
  – transverse boundary



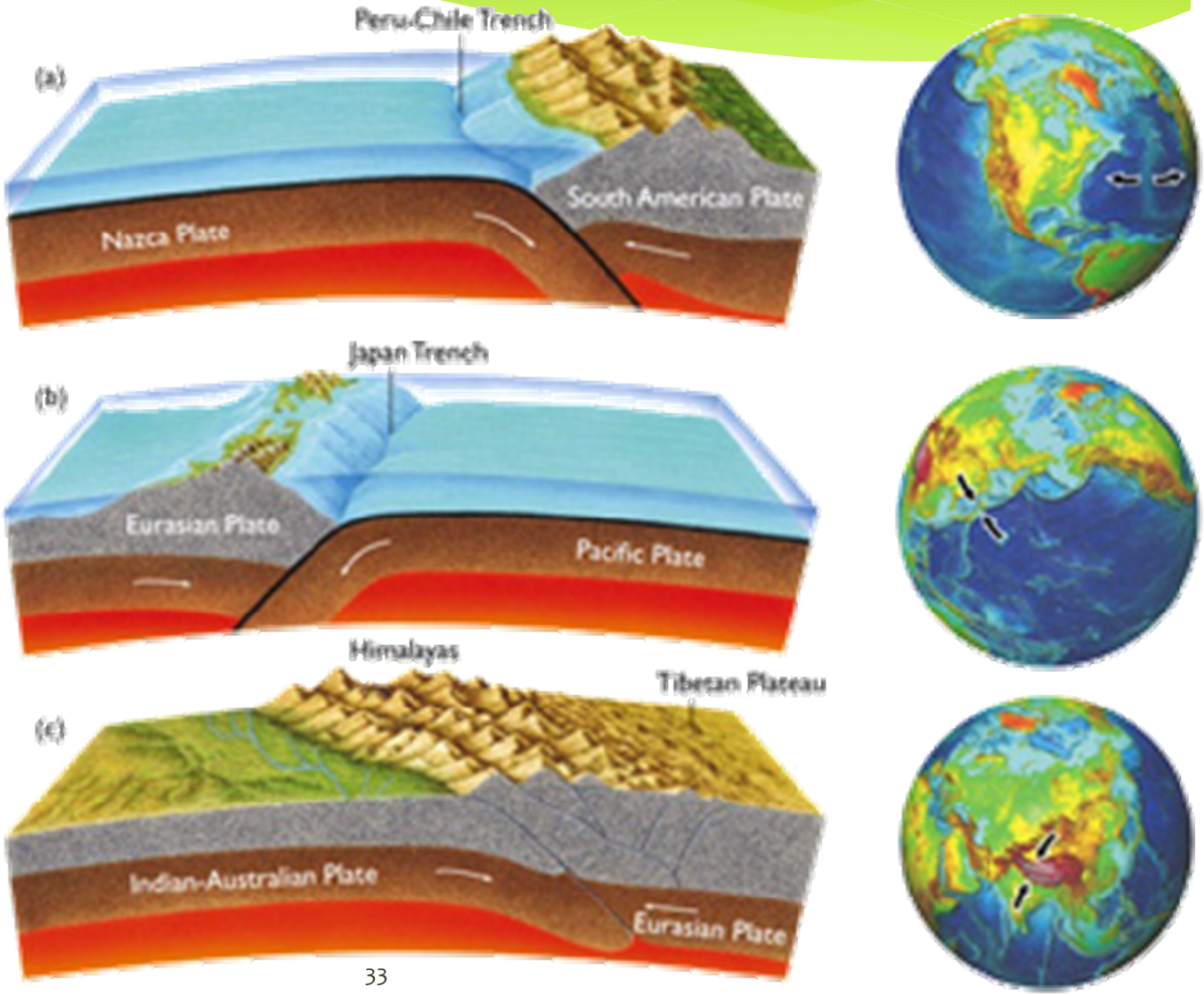
Plates move apart from each other at divergent boundaries

A divergent boundary is where the tectonic plates are separating. In divergent boundaries under the ocean new crust is made from cooling magma oozing up between the plates. Some divergent boundaries on land are places where the crust is sinking downward as it is stretched thin.



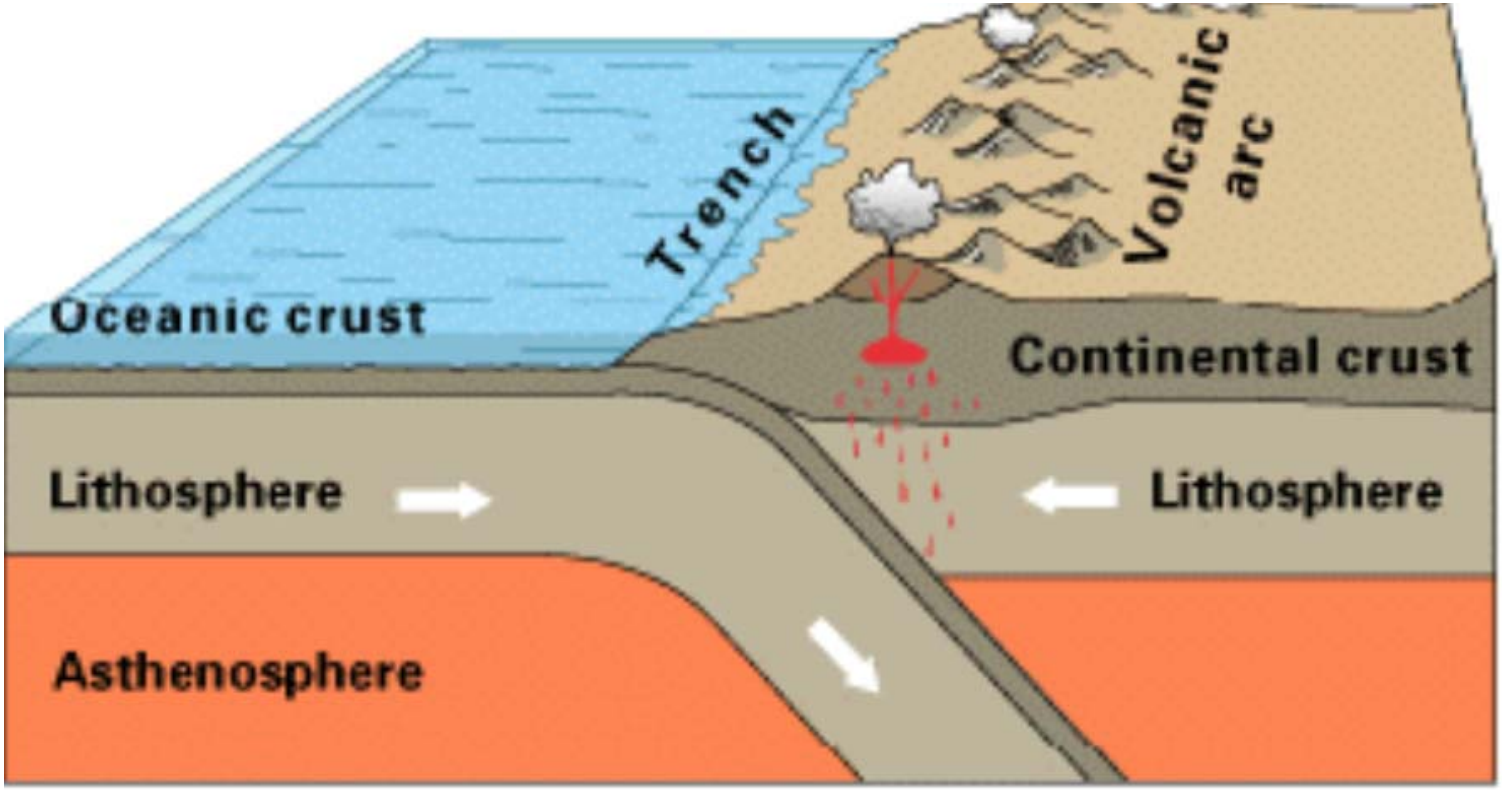
Plates move towards each other at convergent boundaries

A Convergent Boundary is the opposite of a divergent boundary.
Typically you will see a converging boundary on a tectonic plate that is on the opposite side of a divergent boundary .
As the plates collide mountains are often built at these boundaries as one plate is pushed upwards.



Plates move towards each other at convergent boundaries

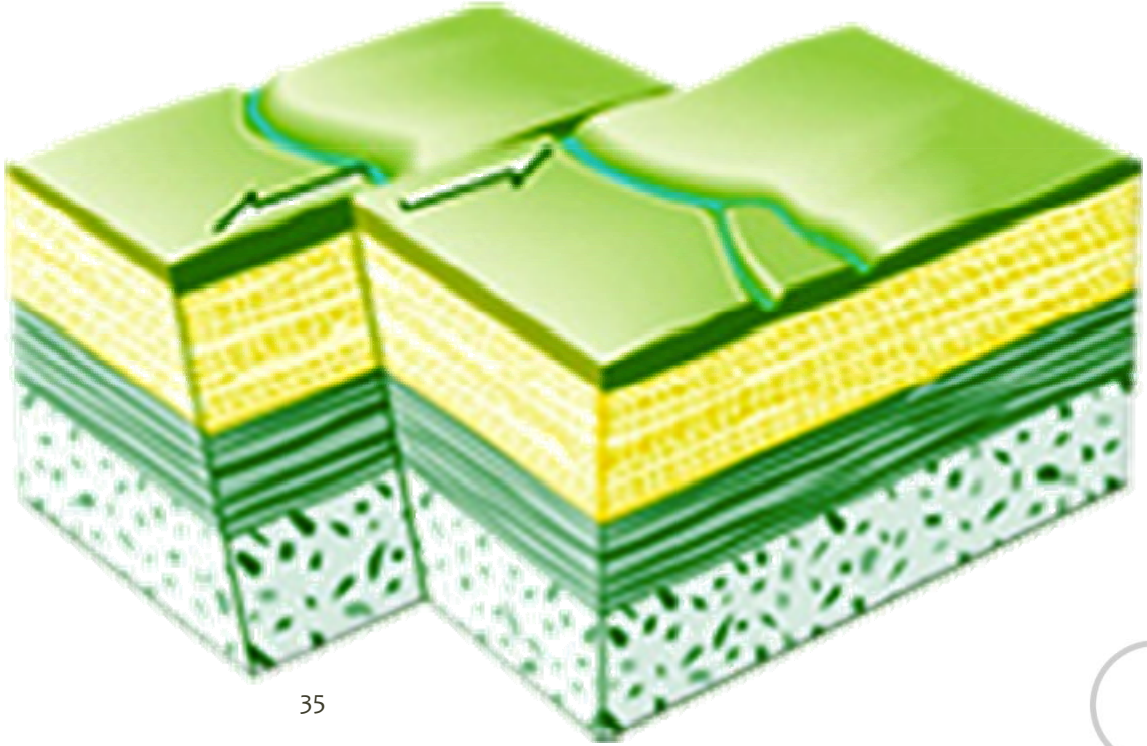
Volcanic activity often occurs at converging boundaries where plates are crashing into each other.
When one plate (usually the lighter continental crust) rides up over the top of the other it's called a **subduction** zone. One plate margin slides under the other and melts into magma as it moves downwards. The magma is then forced up through weak spots in the crust causing a volcano.



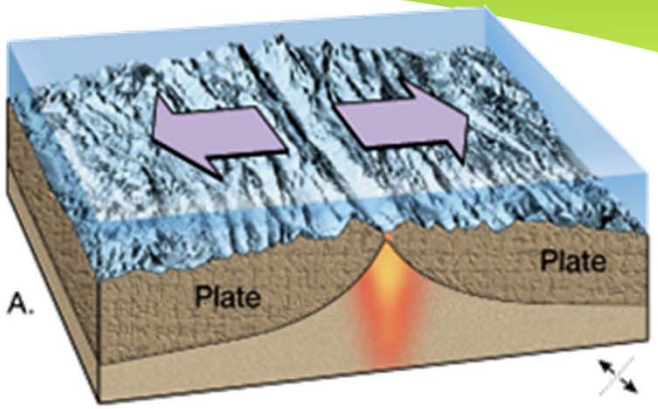
Oceanic-continental convergence

Plates move past each other at transverse boundaries

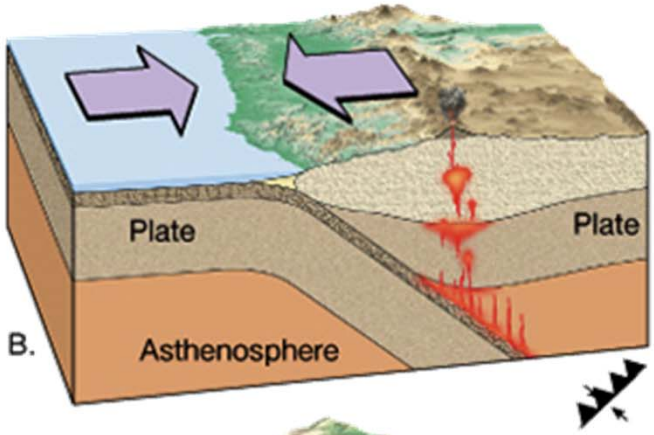
Transverse fault boundaries are places where the two plates are just sliding past each other. This sliding is not a continuous motion but stops and starts as the plates catch against each other then release suddenly. This sudden movement is called an earthquake and they are triggered along fault boundaries.



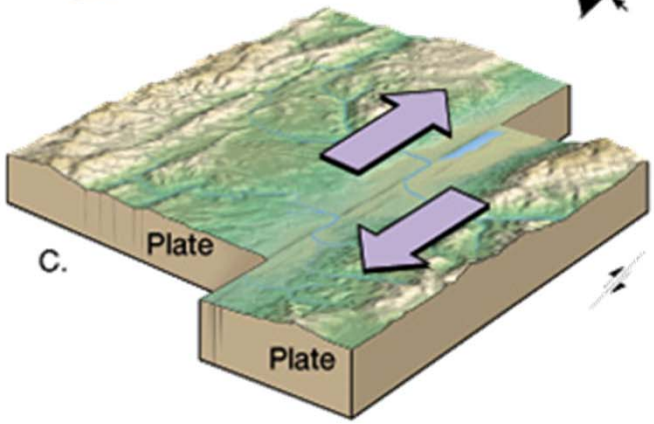
Divergent, convergent and transverse boundaries



Divergent Boundary



Convergent Boundary



Transverse plate Boundary

New Zealand sits on two plate boundaries

New Zealand is on top of the Australian plate to the west and the Pacific plate to the east.
In the lower South Island the Australian plate is pushed under or subducted under the Pacific plate.
In the upper South island the two plates move past each other at a transverse boundary. Creating the Alpine fault.
In the North Island the Pacific plate is subducted under the Australian plate.
There is also a weak area in the crust under the central North Island where magma forces through to create volcanoes.
New Zealand's surface features such as the Southern Alps, Lake Taupo and the central plateau have been the result of this plate activity.

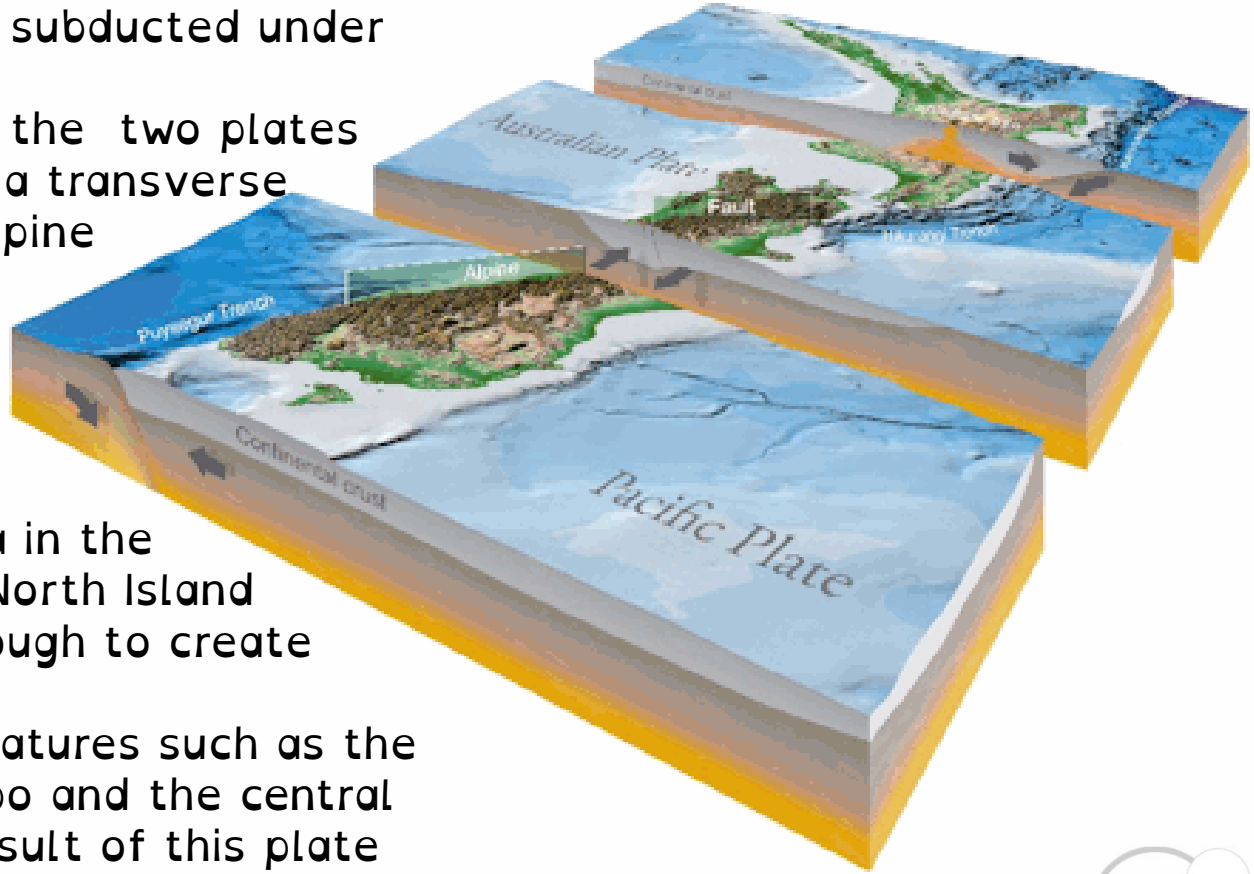


Plate movement results in Volcanic activity

When tectonic plates collide, one plate may slide below the other (called the subduction zone).
The sinking plate melts from heat created by friction.
Magma is produced and may force its way to the surface, creating a volcano.
The explosive effect is known as an eruption.

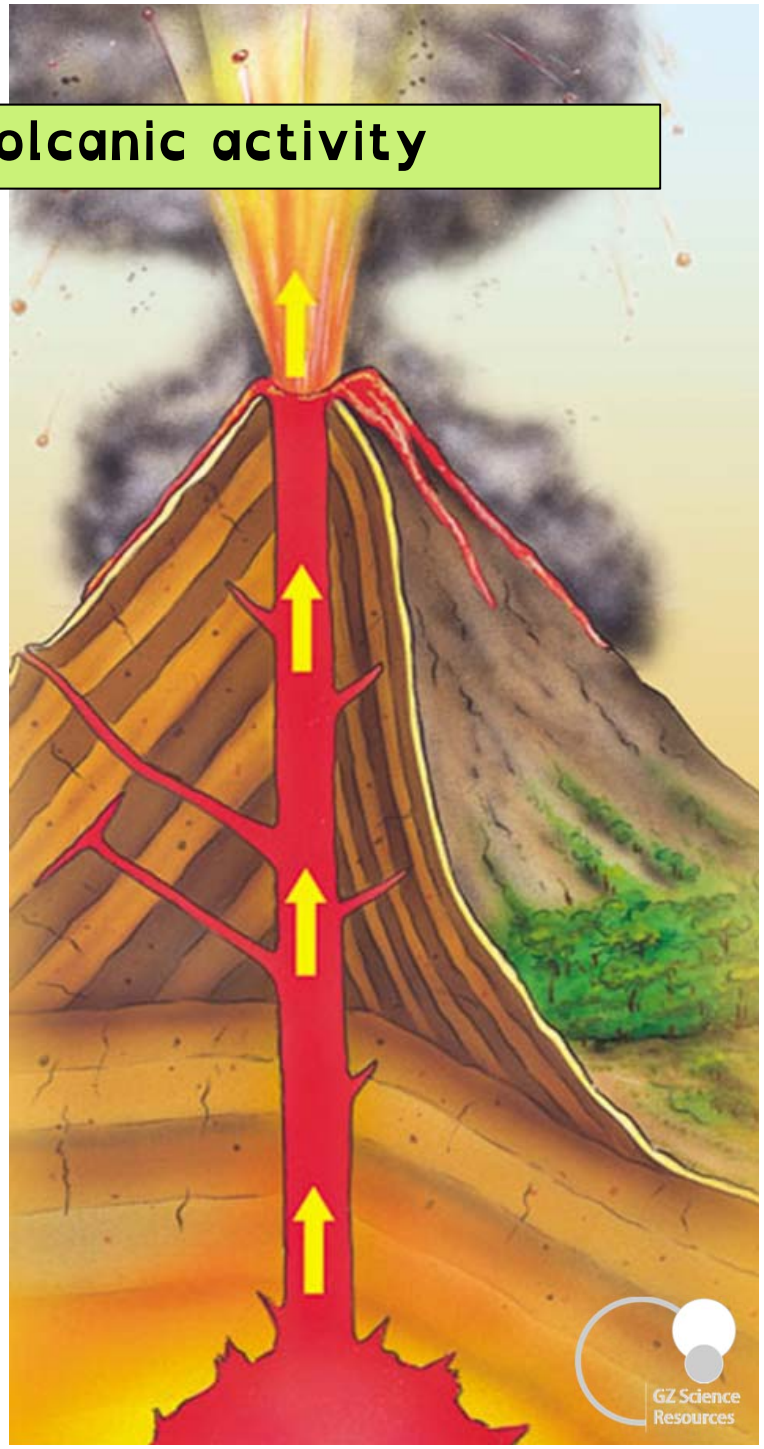
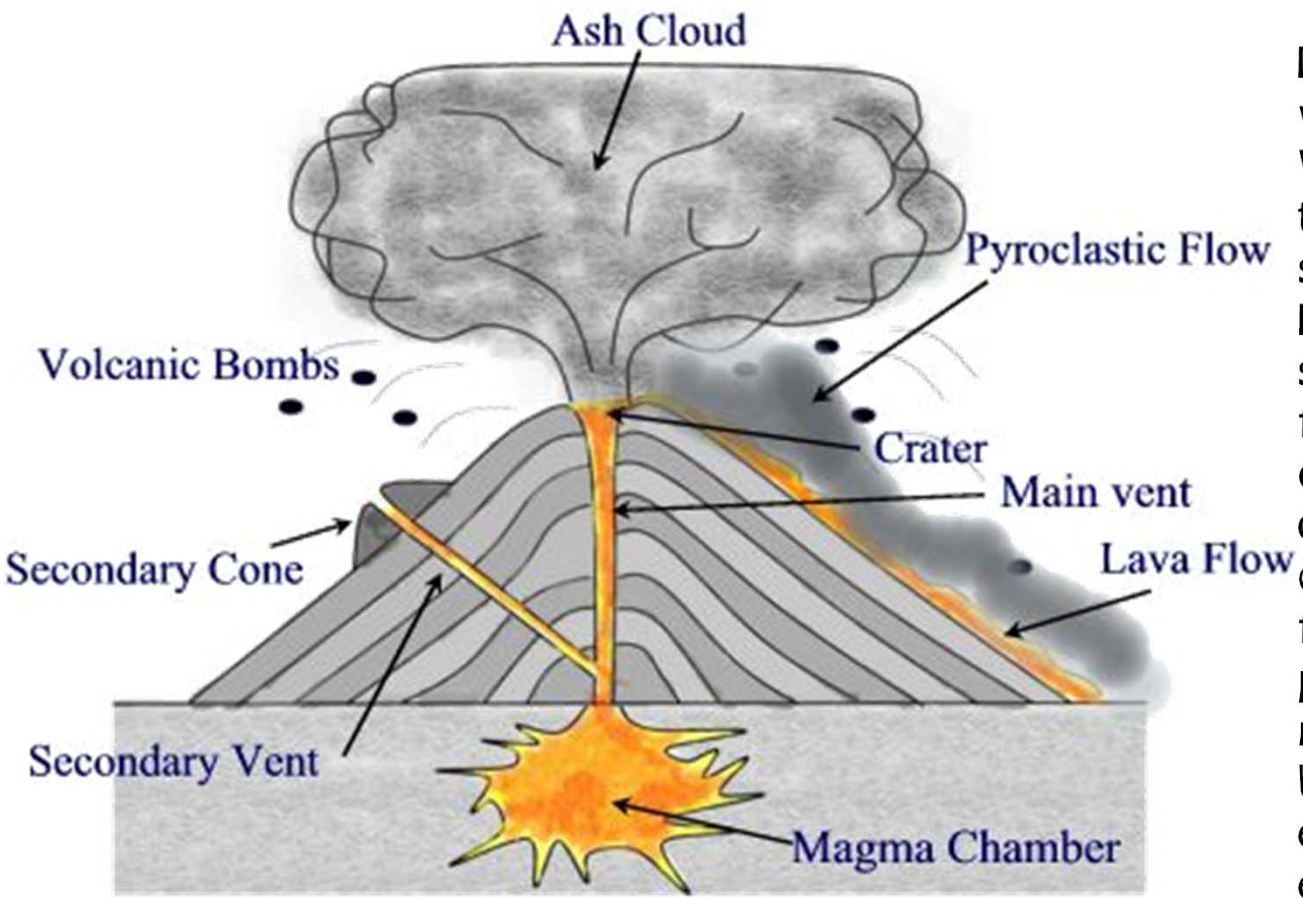


Plate movement results in Volcanic activity

A volcano is a place on the Earth's surface where molten rock and gases erupt through the earth's crust. Some Volcanoes are just cracks at weak points in the earth's crust where lava erupts, and some are domes, shields, or mountain-like structures with a crater at the summit.

Plate movement results in Volcanic activity



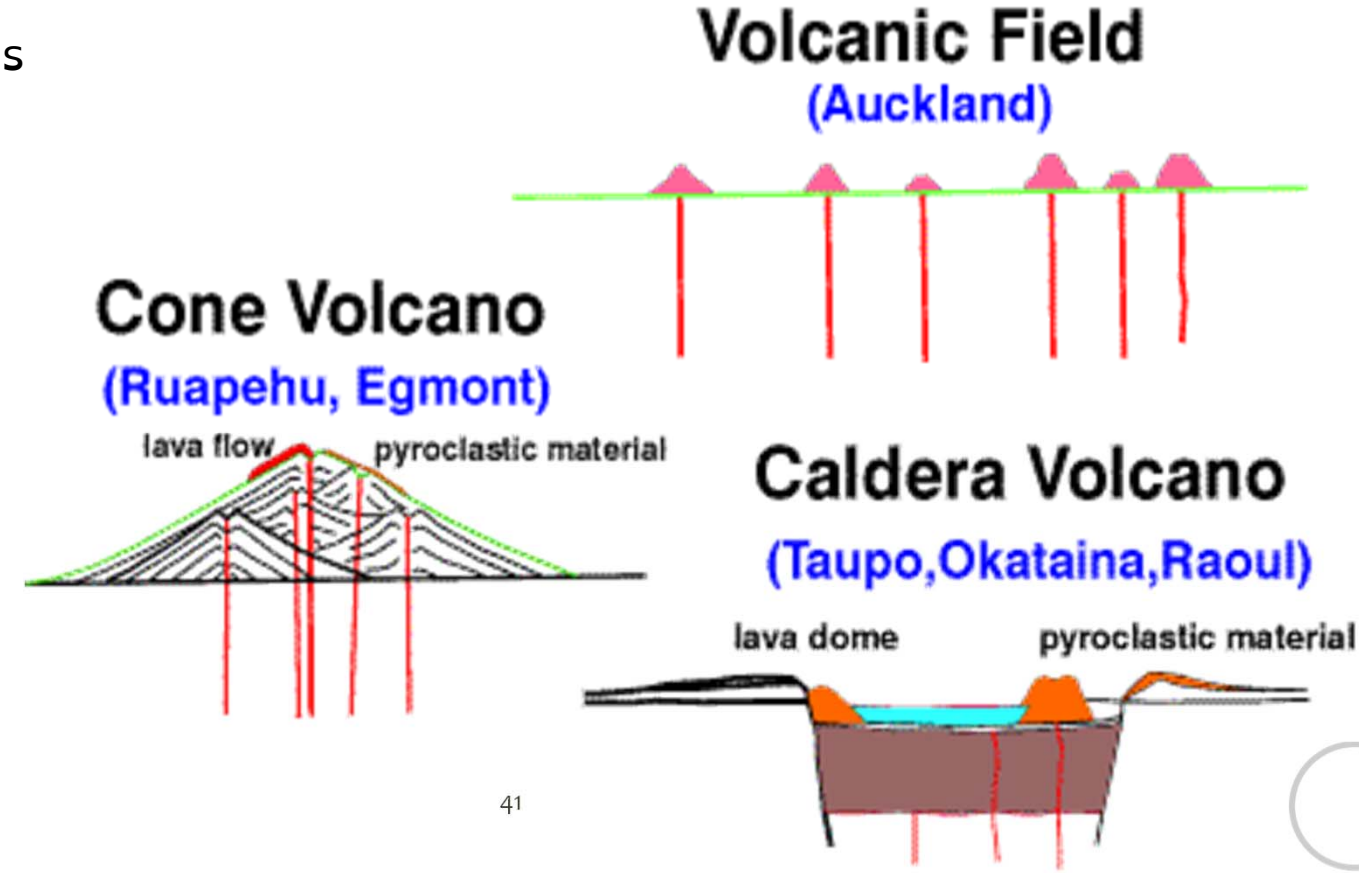
Main Features of a Volcano

Magma is molten rock within the Earth's crust. When magma erupts through the earth's surface it is called lava. Lava can be thick and slow-moving or thin and fast-moving. Rock also comes from volcanoes in other forms, including ash, cinders (bits of fragmented lava), and pumice (light-weight rock that is full of air bubbles and is formed in explosive volcanic eruptions).

Volcanic activity in New Zealand

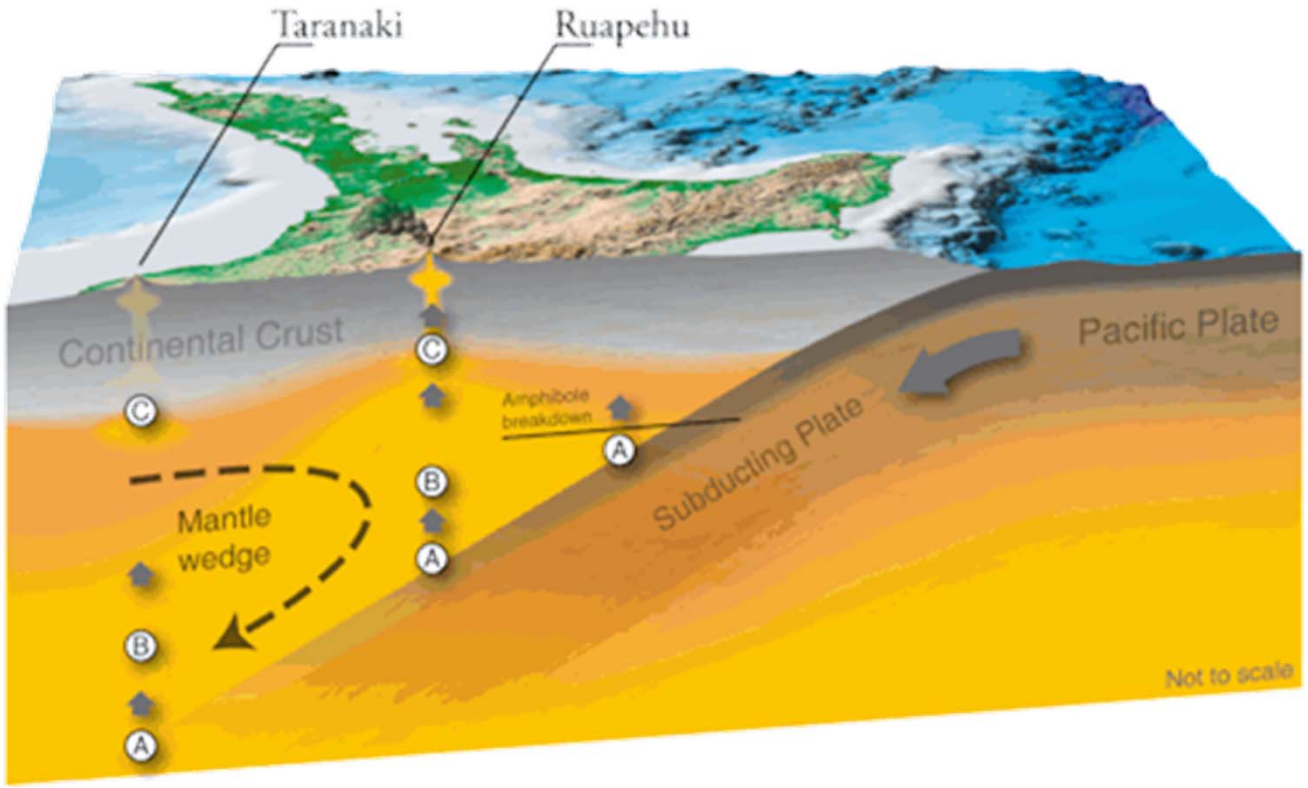
New Zealand has a lot of active volcanoes and a high frequency of eruptions. Most New Zealand volcano activity in the last 2 million years has occurred in the extremely active Taupo Volcanic Zone . We have three major types of volcanoes in New Zealand. The **Volcanic field** is seen in areas such as Auckland. The **cone volcano** includes three frequently active cone volcanoes ;Ruapehu, Tongariro/Ngauruhoe, and White Island.

The **Caldera volcano** includes Lake Taupo, Okataina (near Rotorua) and Raoul Island.



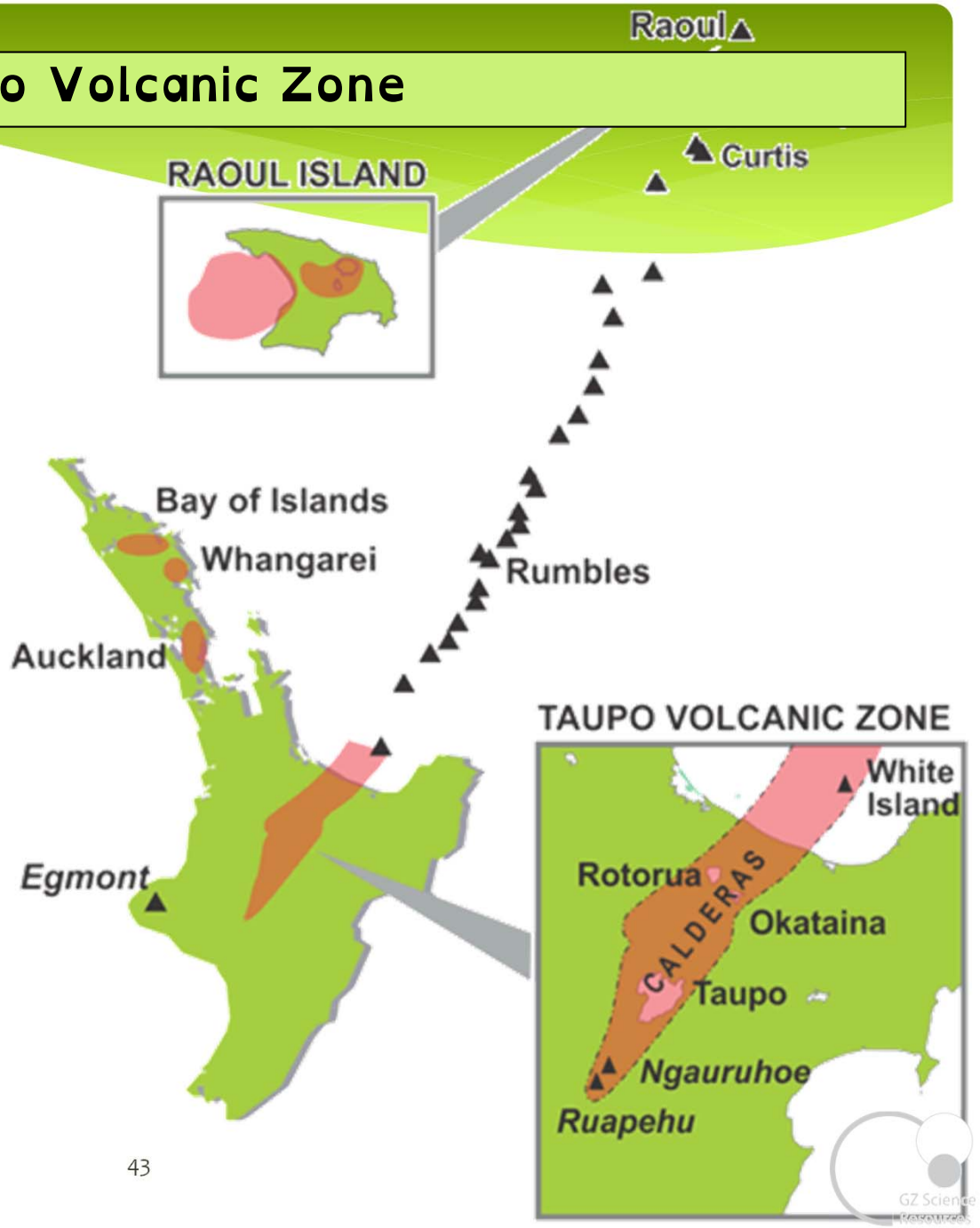
Volcanic activity in New Zealand

New Zealand has so many active and extinct volcanos because we sit on top of a subducting plate. The hot magma between the two plates is squeezed up through the crust. New Zealand lies on the **Pacific Ring of Fire**, where movement of the Pacific plate causes many volcanoes. Some New Zealand volcanoes lie under the ocean on the Kermadec Ridge.

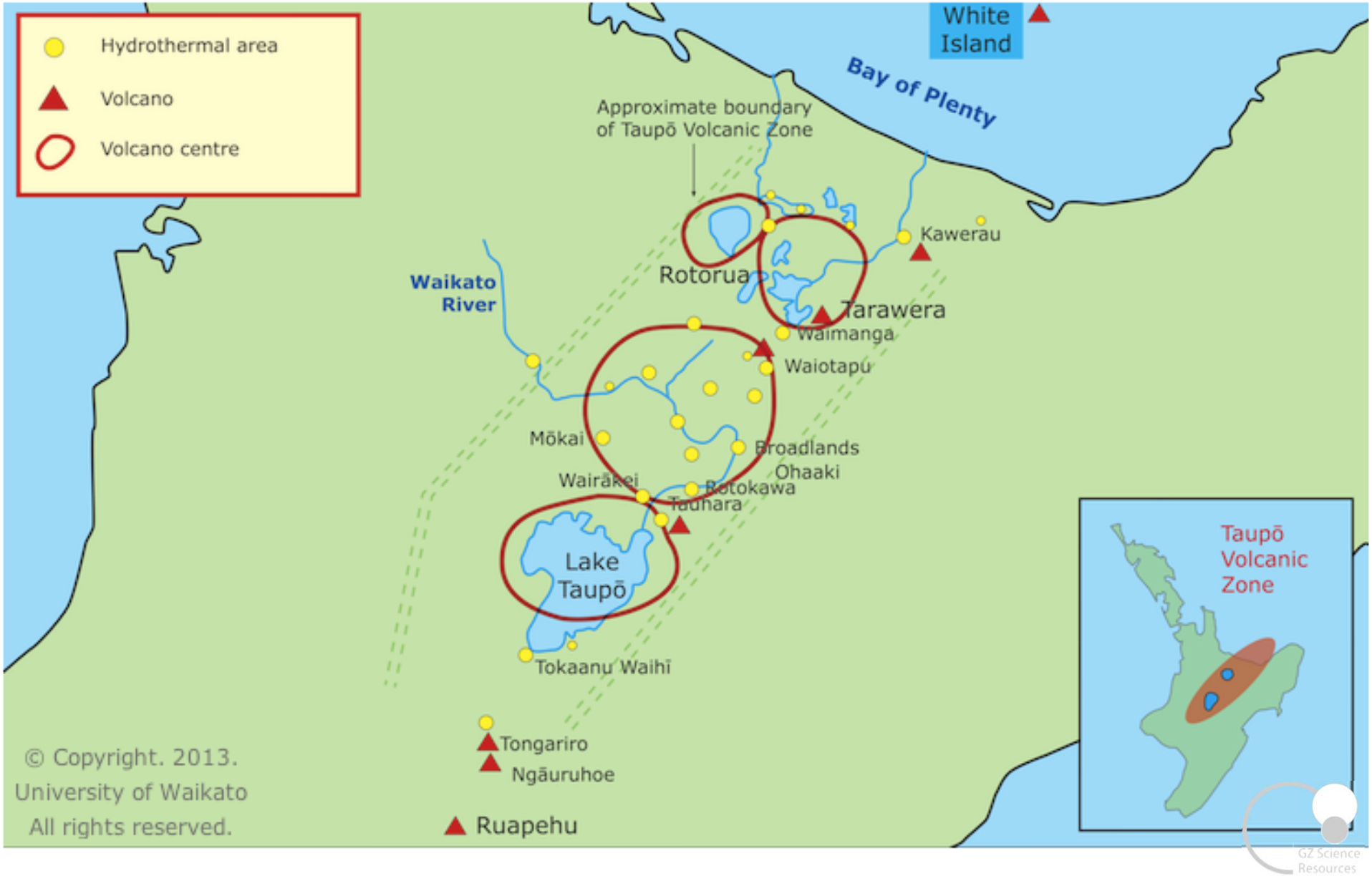


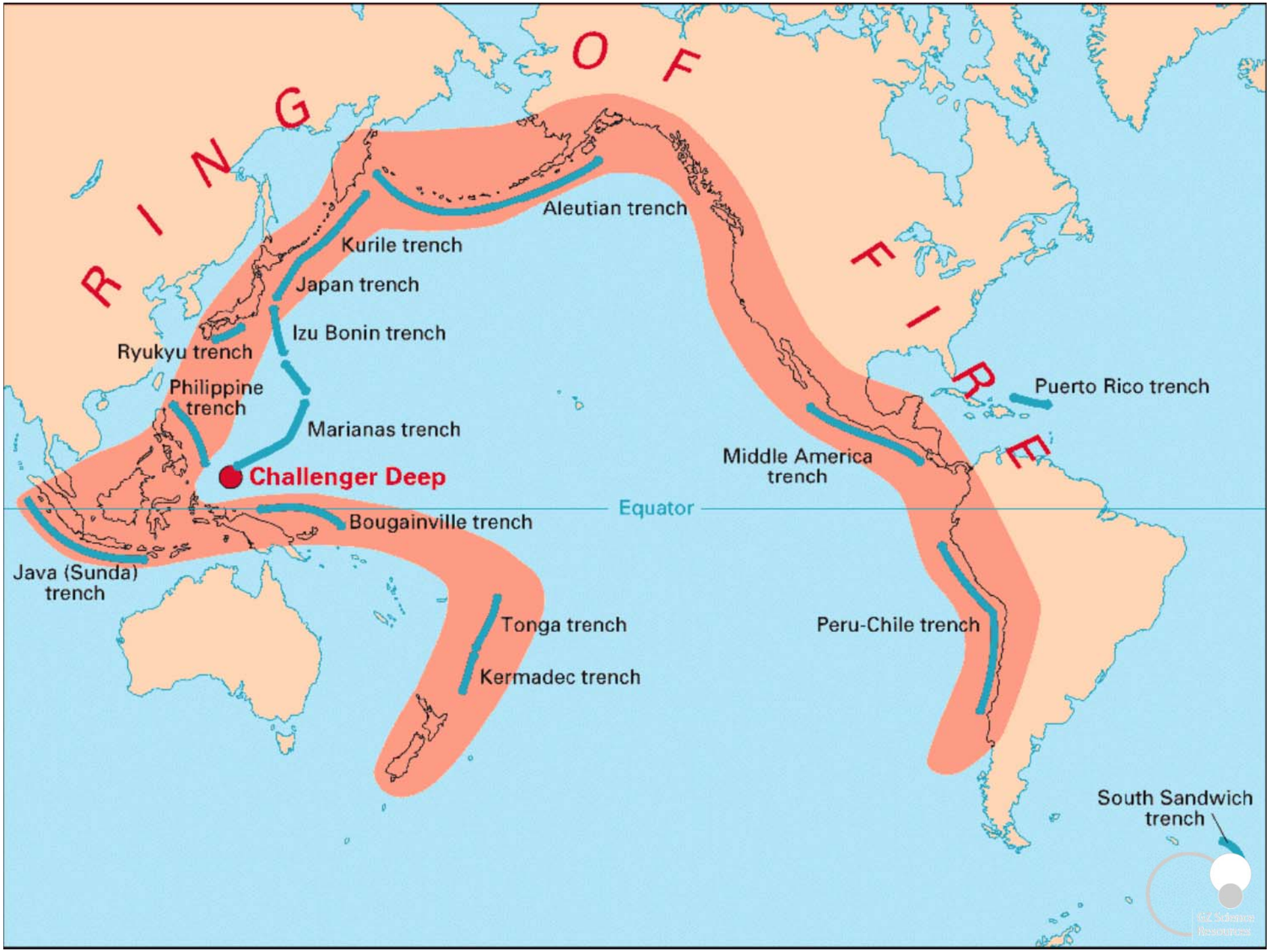
Taupo Volcanic Zone

The Taupō Volcanic Zone extends from Mt Ruapehu through Rotorua to **White Island** and is the front of a wedge where the Australian and Pacific tectonic plates collide

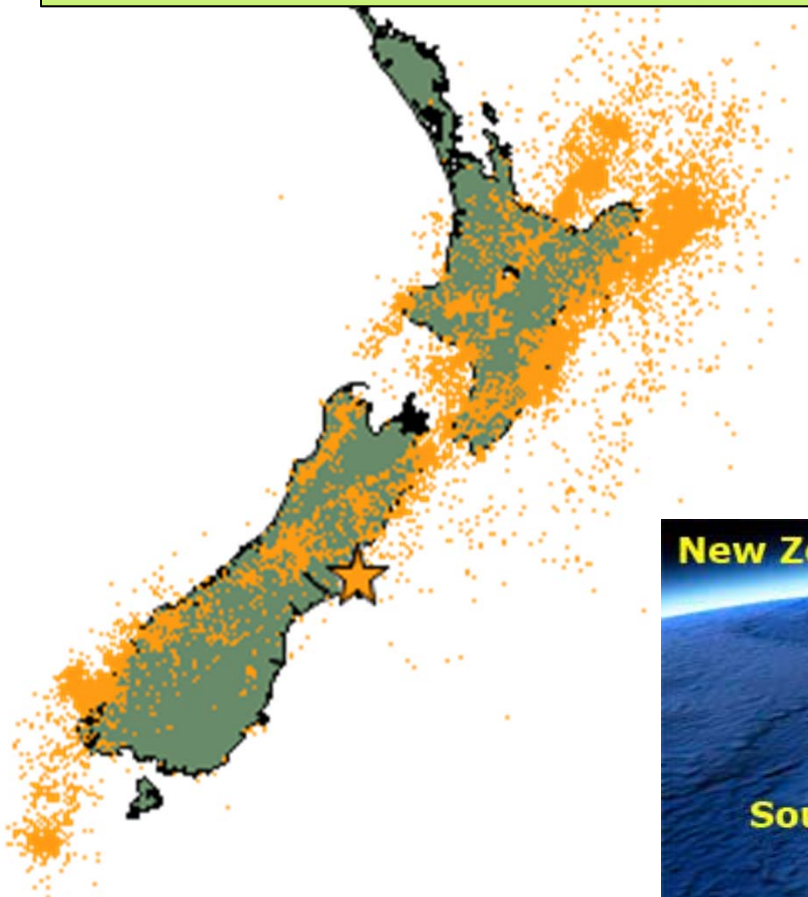


Volcanic activity in New Zealand



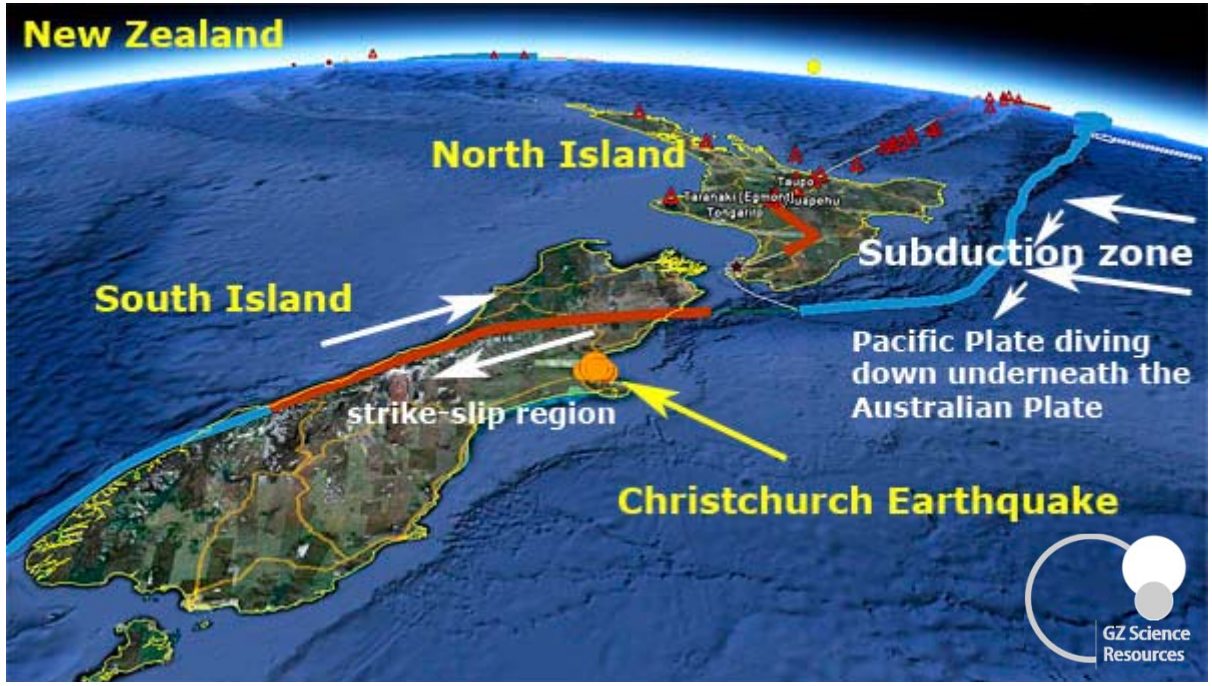

RING OF FIRE
Aleutian trench
Kurile trench
Japan trench
Izu Bonin trench
Ryukyu trench
Philippine trench
Marianas trench
Challenger Deep
Bougainville trench
Equator
Java (Sunda) trench
Tonga trench
Kermadec trench
Middle America trench
Puerto Rico trench
Peru-Chile trench
South Sandwich trench

Earthquakes are the result of earths plates moving past each other



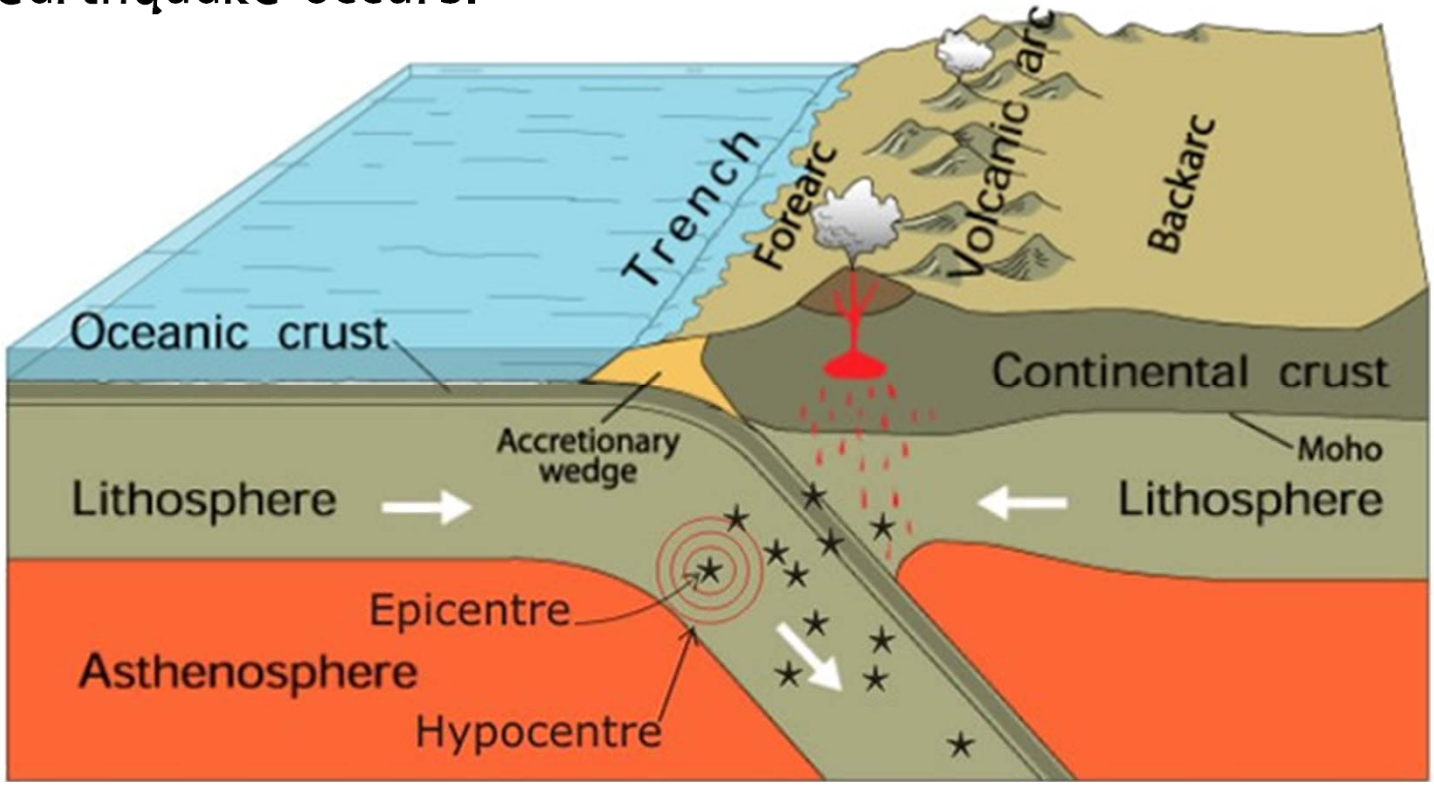
New Zealand has a high number of earthquakes compared to some other countries around the world. These earthquakes occur because of our location above two tectonic plates.

Shallow earthquakes in New Zealand in the past 10 years 2001 - 2011

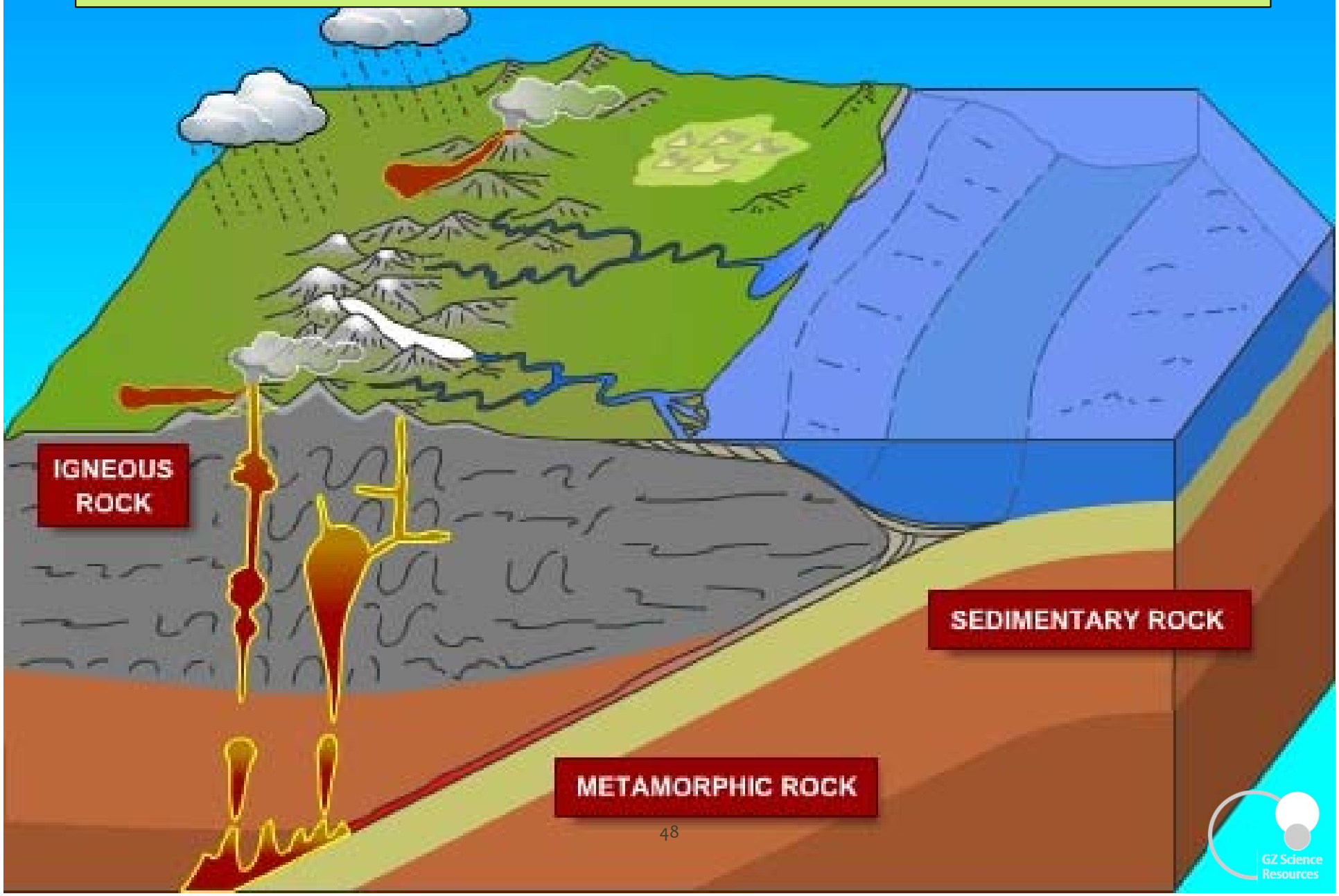


Earthquakes are the result of earths plates moving past each other

As plates move the strain causes brittle rock to crack.
These cracks, called faults, are often weak zones where more movement or cracking may occur.
Constant movement of plates causes pressure to build up at faults, and at the boundaries of the plates.
If there is a sudden slippage of rock, this pressure is released quickly and an earthquake occurs.



The three main types of rock



The three main types of rock

Igneous

pumice 	rhyolite 	andesite 	basalt 	obsidian 
scoria 	granite 	diorite 	gabbro 	

Metamorphic

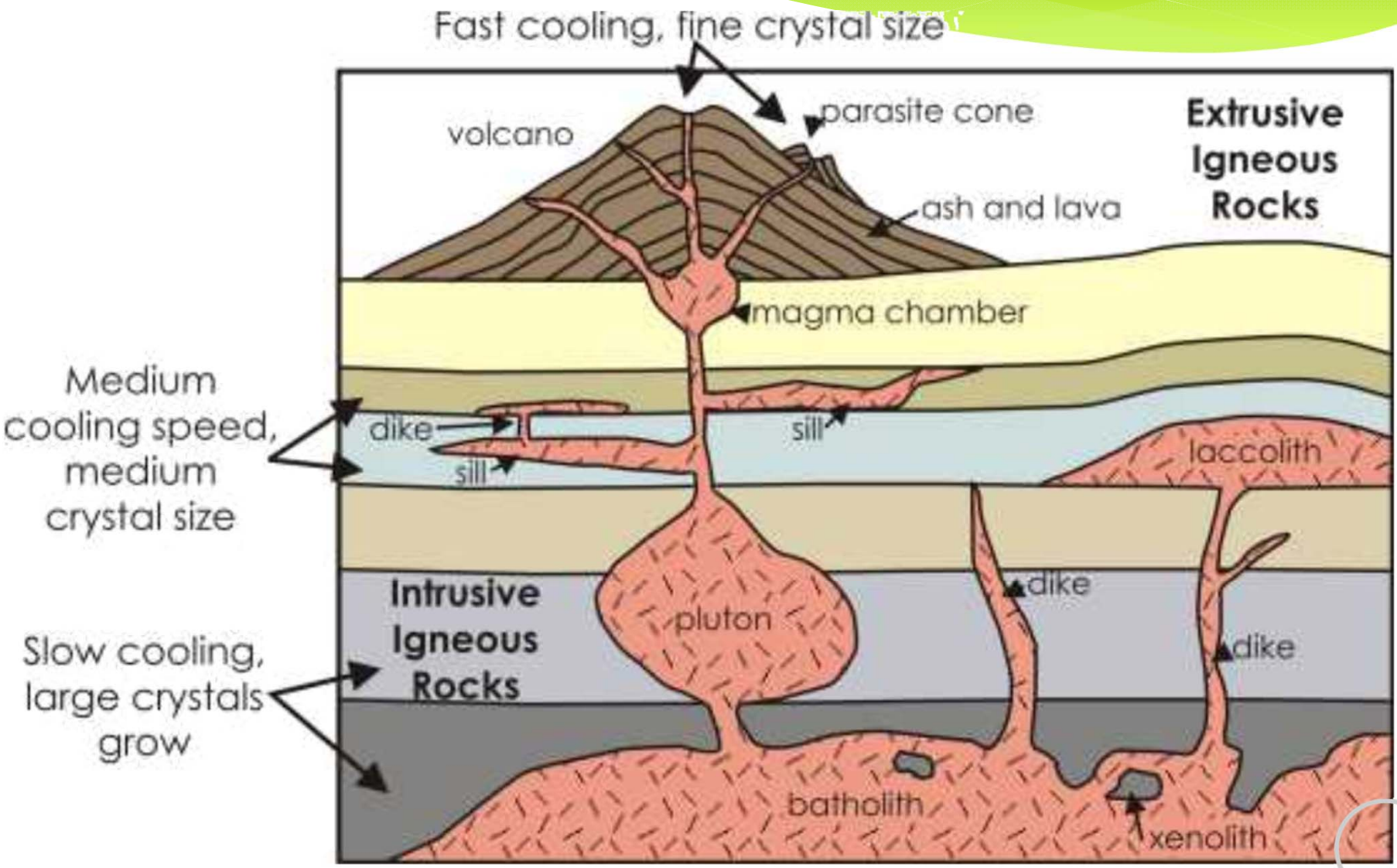
gneiss 	marble 	slate 	schist 

Sedimentary

conglomerate 	sandstone 	siltstone 
mudstone 	coal 	limestone 

Igneous rock classification

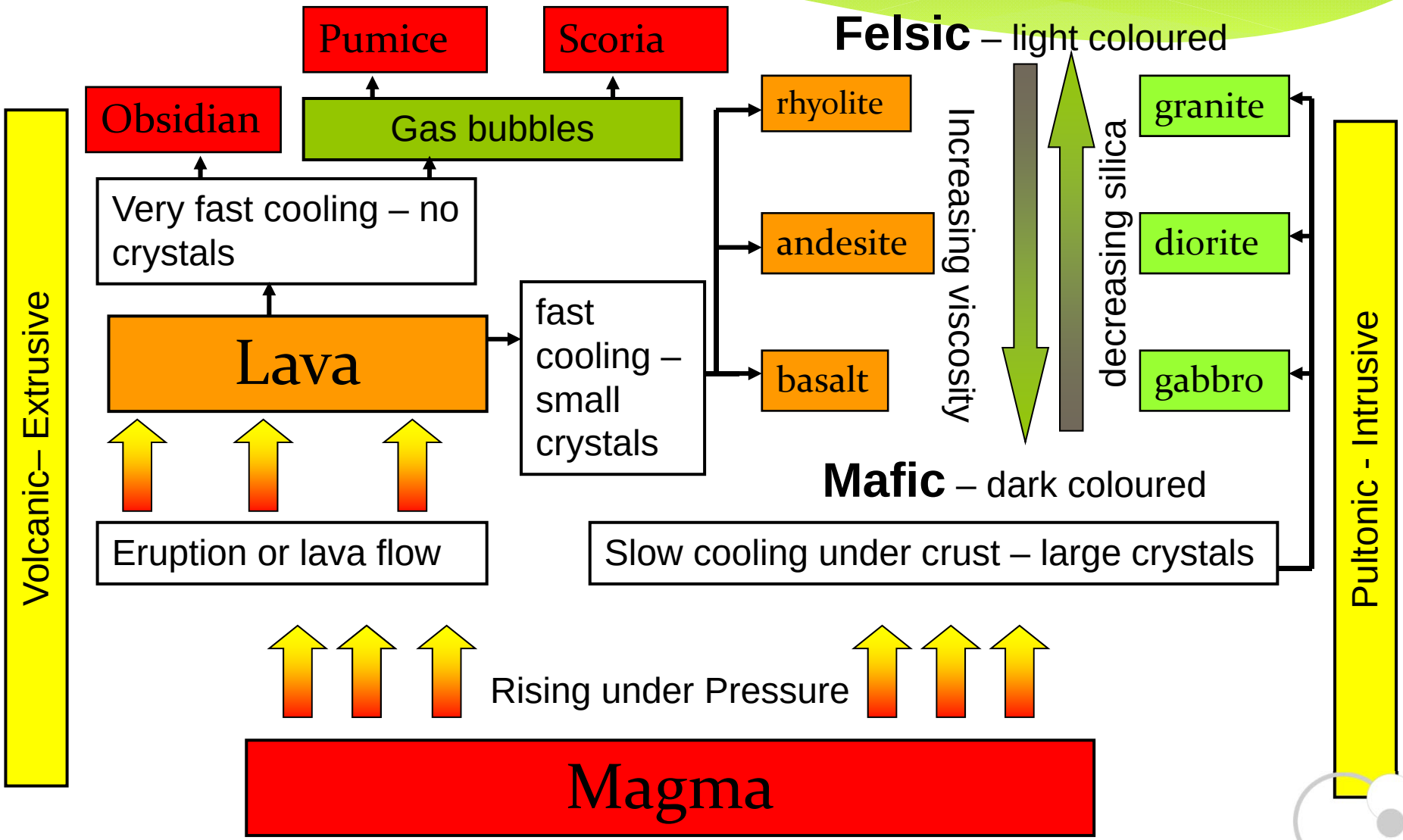
Igneous rock classification



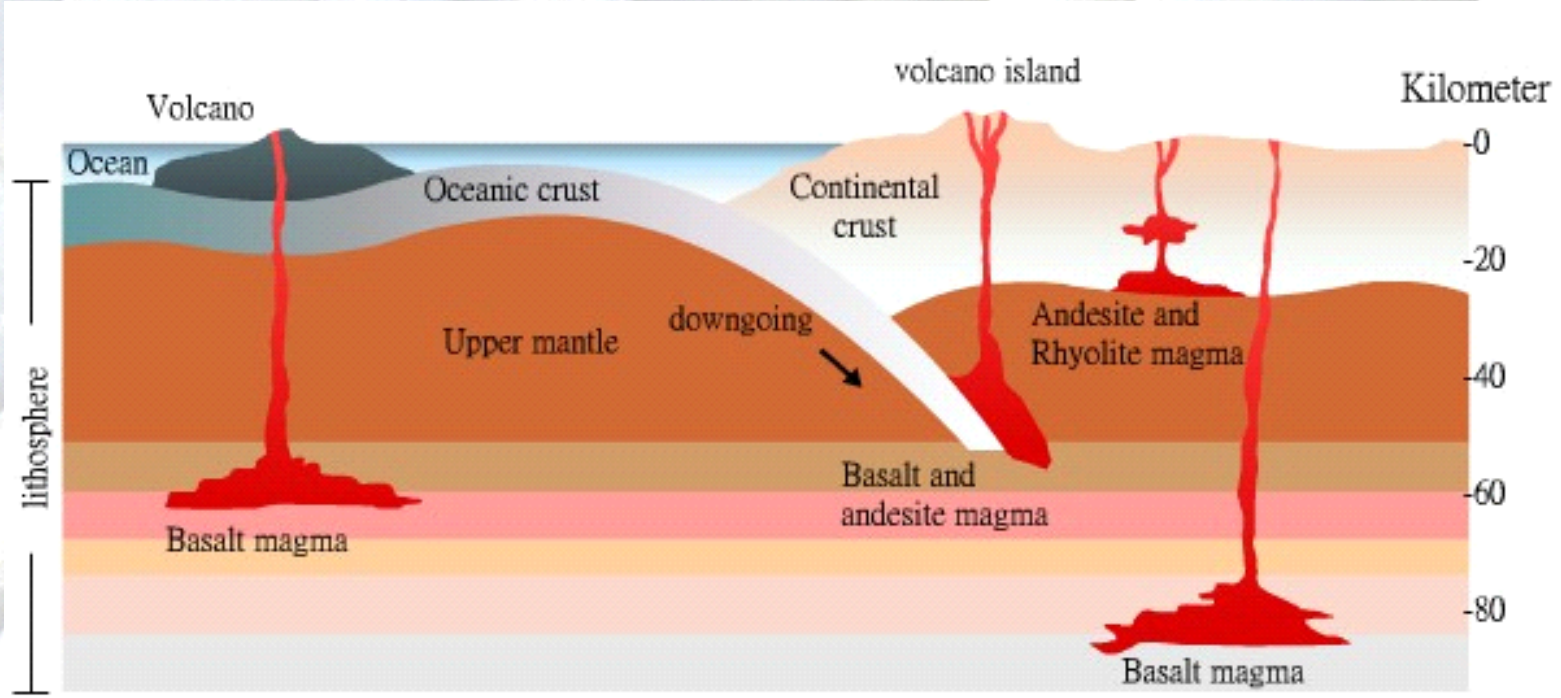
Igneous rock formation

Volcanic (or Extrusive) igneous rocks form when molten rock reaches the earth's surface and cools. Air and moisture cool the lava rapidly. The quick cooling doesn't allow the formation of large crystals, so most volcanic rocks have small crystals or none at all. In some volcanic rocks, like pumice and scoria, air and other gases are trapped in the lava as it cools. We can see holes remaining in the rock where the bubbles of gas were located.	With **Plutonic (Intrusive)** igneous rocks the molten rock cools before it reaches the surface. Molten rock that is still underground is called magma. Magma originates from the melting of Earth's crust and upper mantle. This melting occurs about a depth of 60 to 200 km. Molten rock that cools before it reaches the surface hardens to become plutonic igneous rock. Because it forms deep beneath Earth's surface, it has more time to cool and it develops large crystals.

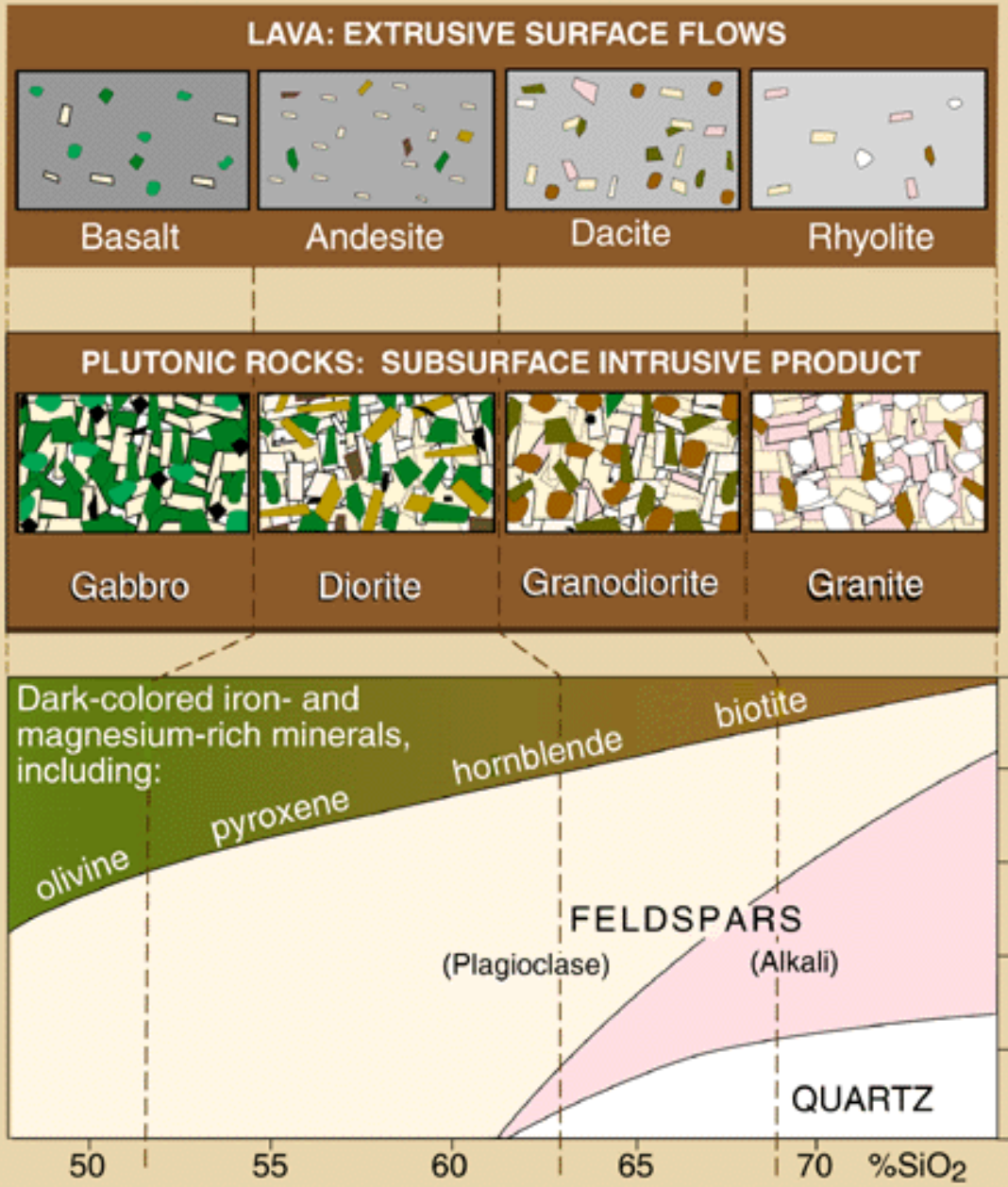
Igneous rock formation



Igneous rock formation



COMPONENTS OF IGNEOUS ROCKS



Lava flows typically produce rocks with 0-50% crystals (minerals) suspended in a fine-grained groundmass of glass and/or microscopic minerals.

Volcanic rock name

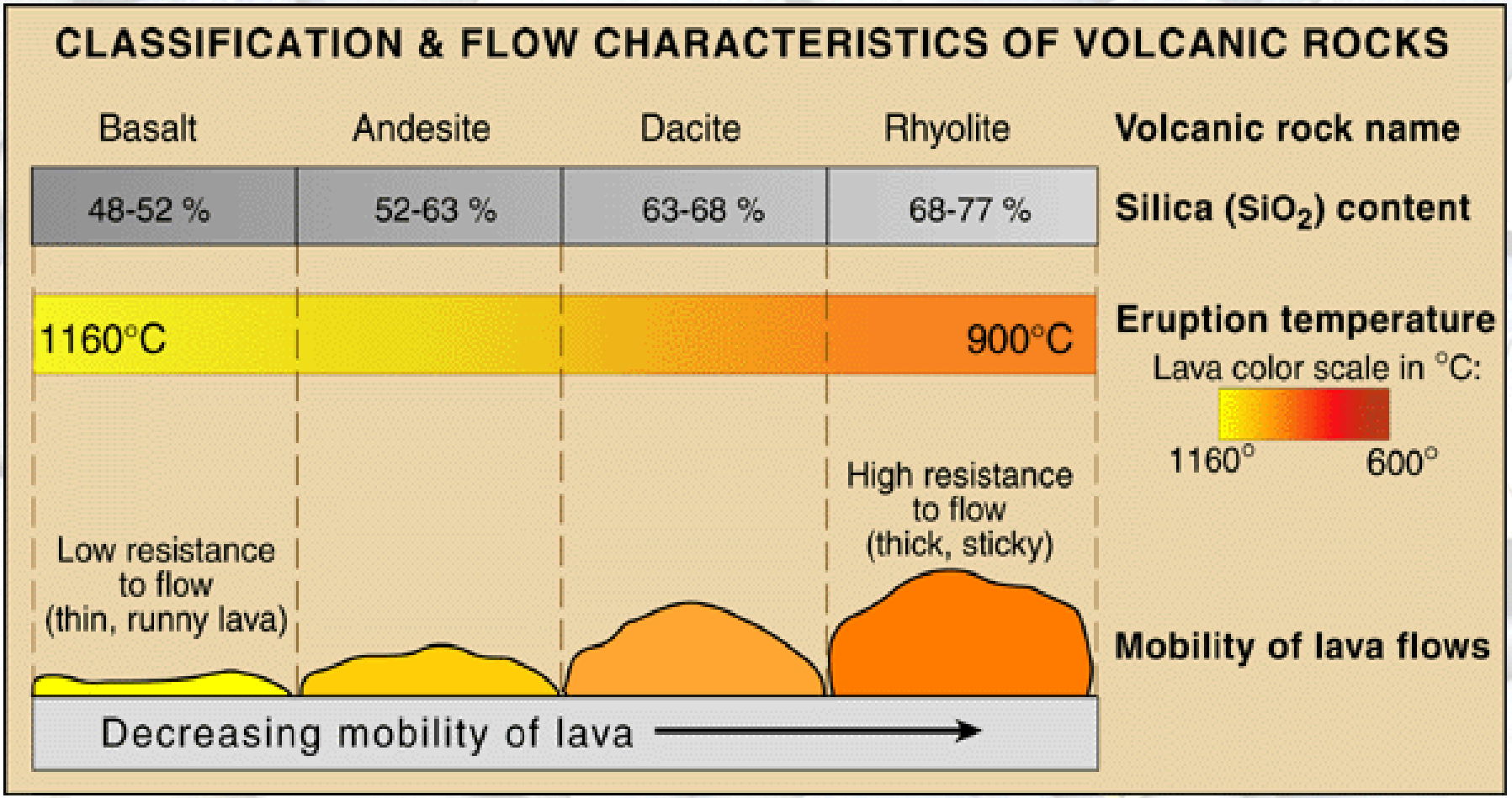
Coarse-grained rock; entirely crystalline with interlocking minerals in the proportions below. (Colors roughly correlate to graph below.)

Plutonic rock name

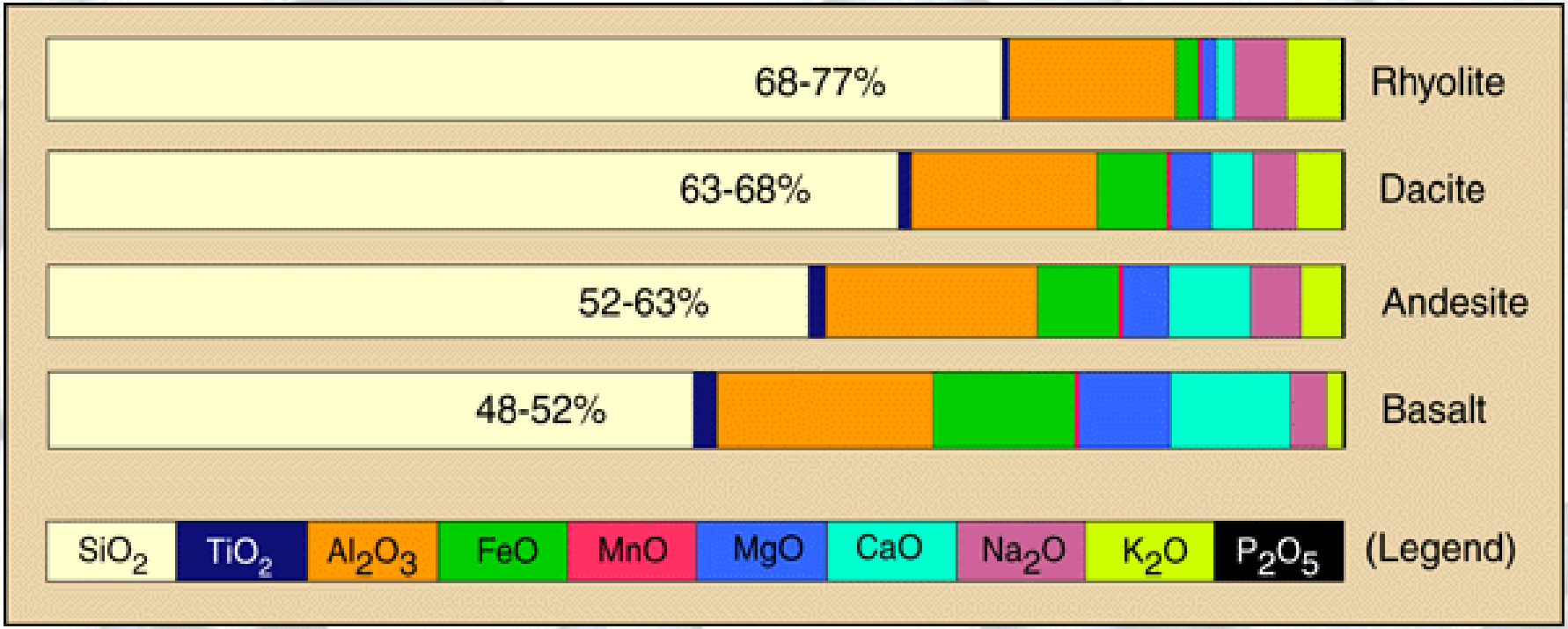
Volume percent of minerals present in igneous rocks.

This generalized guide shows proportions of common minerals likely to be present in an igneous rock. (See text below on how to calculate.)

Plutonic rocks are entirely crystalline and have a larger variety of unusual minerals than volcanic rocks.



The behavior of a lava flow depends primarily on its viscosity (resistance to flow), slope of the ground over which it travels, and the rate of lava eruption. Because basalt contains the least amount of silica and erupts at the highest temperature compared to the other types of lava, it has the lowest viscosity (the least resistance to flow). Thus, basalt lava moves over the ground easily, even down gentle slopes. Dacite and rhyolite lava, however, tend to pile up around a vent to form short, stubby flows or mound-shaped domes.

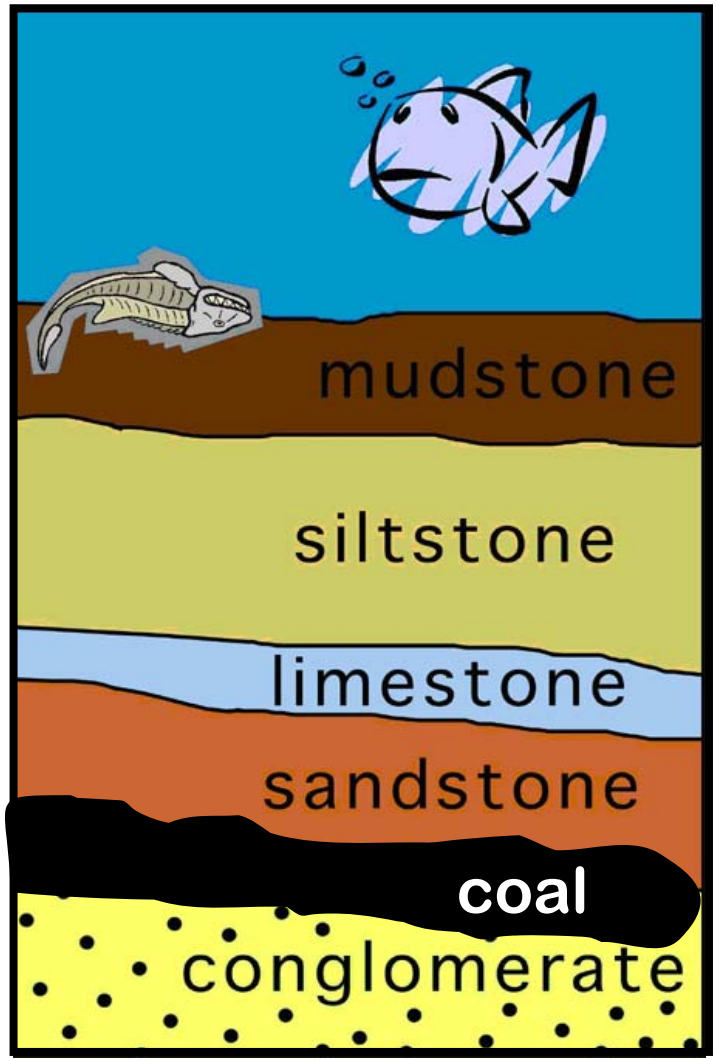


Volcanic rocks are typically divided into four basic types according to the amount of silica (SiO_2) in the rock

The bar graph shows the average concentration of each major element for the four basic types of volcanic rock.

Sedimentary rock Classification

Related to water flow



Mudstone is a fine-grained rock whose original particles were clays or muds. Mud rocks, such as mudstone and shale (that show layers) comprise some 65% of all sedimentary rocks. Mudstone may show cracks or fissures, like a sun-baked clay deposit.

Siltstone is a sedimentary rock which has a composition intermediate in grain size between the coarser sandstones and the finer mudstones.

Sandstone is composed mainly of sand-size grains. Sandstone may be any colour. Because of the hardness of the individual grains, uniformity of grain size, sandstone is an excellent material for building and paving

A **conglomerate** is a rock consisting of individual stones that have become cemented together. Conglomerates consist of rounded fragments.

Sedimentary rock Classification

Related to environment

Limestone composed largely of calcium carbonate. The primary source of limestone is most commonly marine organisms. These organisms secrete shells that are deposited on ocean floors. This layer of sediments is covered by further sediments, which over time with heat and pressure is changed into limestone. Limestone is revealed when Earth movements uplift the rock.

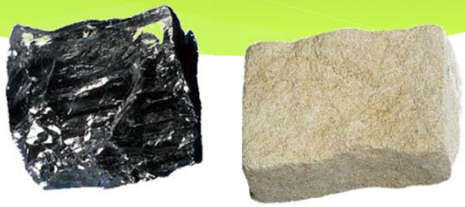
Coal is a fossil fuel formed in swamps where plant remains decay slowly without oxygen. It is composed primarily of carbon. It is the largest single source of fuel for the generation of electricity world-wide, as well as the largest source of carbon dioxide emissions. Coal is extracted from the ground by coal mining either underground mining or open cast mines.

Sedimentary rock Formation

Related to water flow

Increasing particle (clast) size

Mudstone | Siltstone | Sandstone | Conglomerate



Coal | Limestone

Related to environment

Uplift (Geological forces) and Exposure (environmental forces)

Compaction and Cementation

Pressure over time

Deposition

Transportation

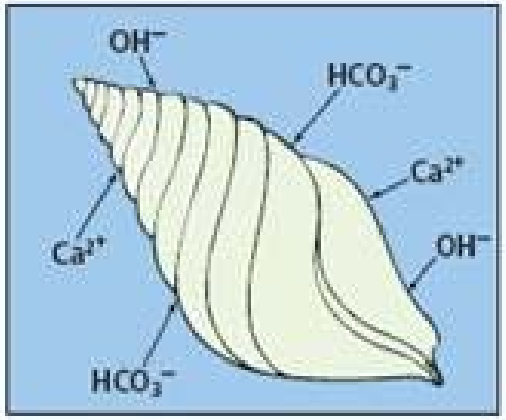
Weathering and Erosion

Environmental forces

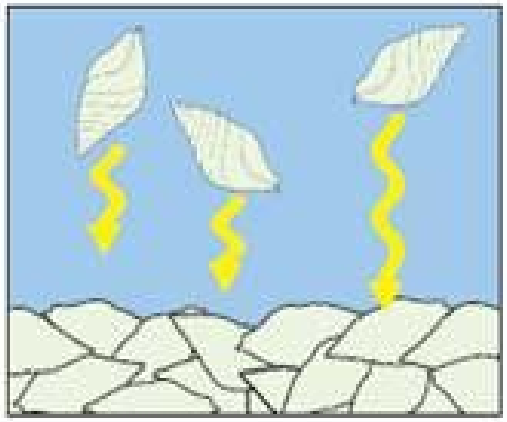
Parent material

Metamorphic Rock | Igneous Rock | plants | Marine organisms

Limestone formation



Organisms that live in lakes or oceans take chemicals from the water and produce the mineral calcium carbonate, $CaCO_3$. They use the $CaCO_3$ to build their shells or skeletons.



When the organisms die, the hard remains that are made of $CaCO_3$ settle to the lake or ocean floor.

The shells of the dead organisms pile up. Eventually, the layers are compacted and cemented to form limestone.

Metamorphic rock classification

Granite → **Gneiss**

Limestone → **Marble**

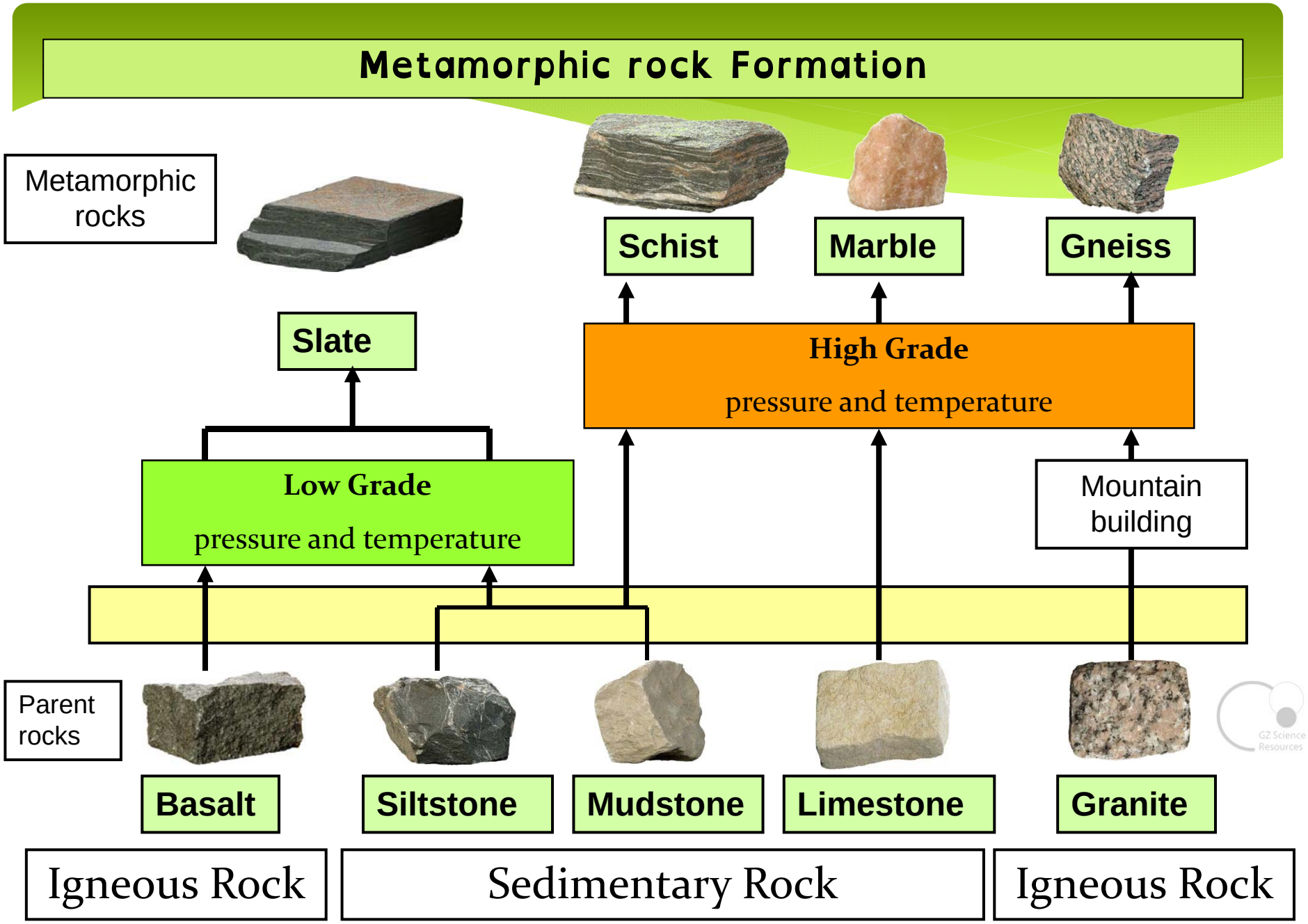
Mudstone
Siltstone → **Schist**

Mudstone / Siltstone → **Slate**

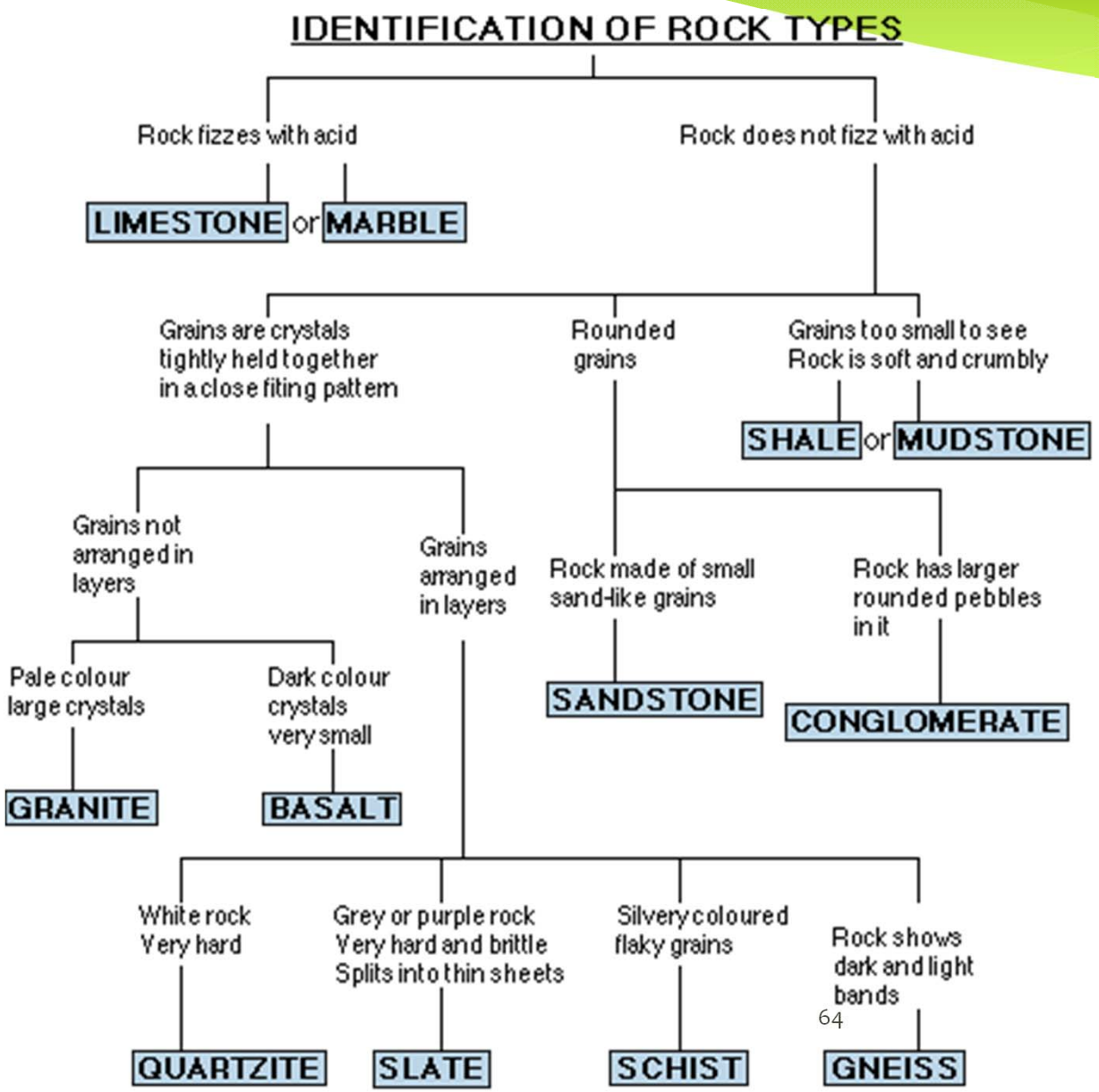
Basalt → **Slate**

Heat and Pressure

Metamorphic rock Formation

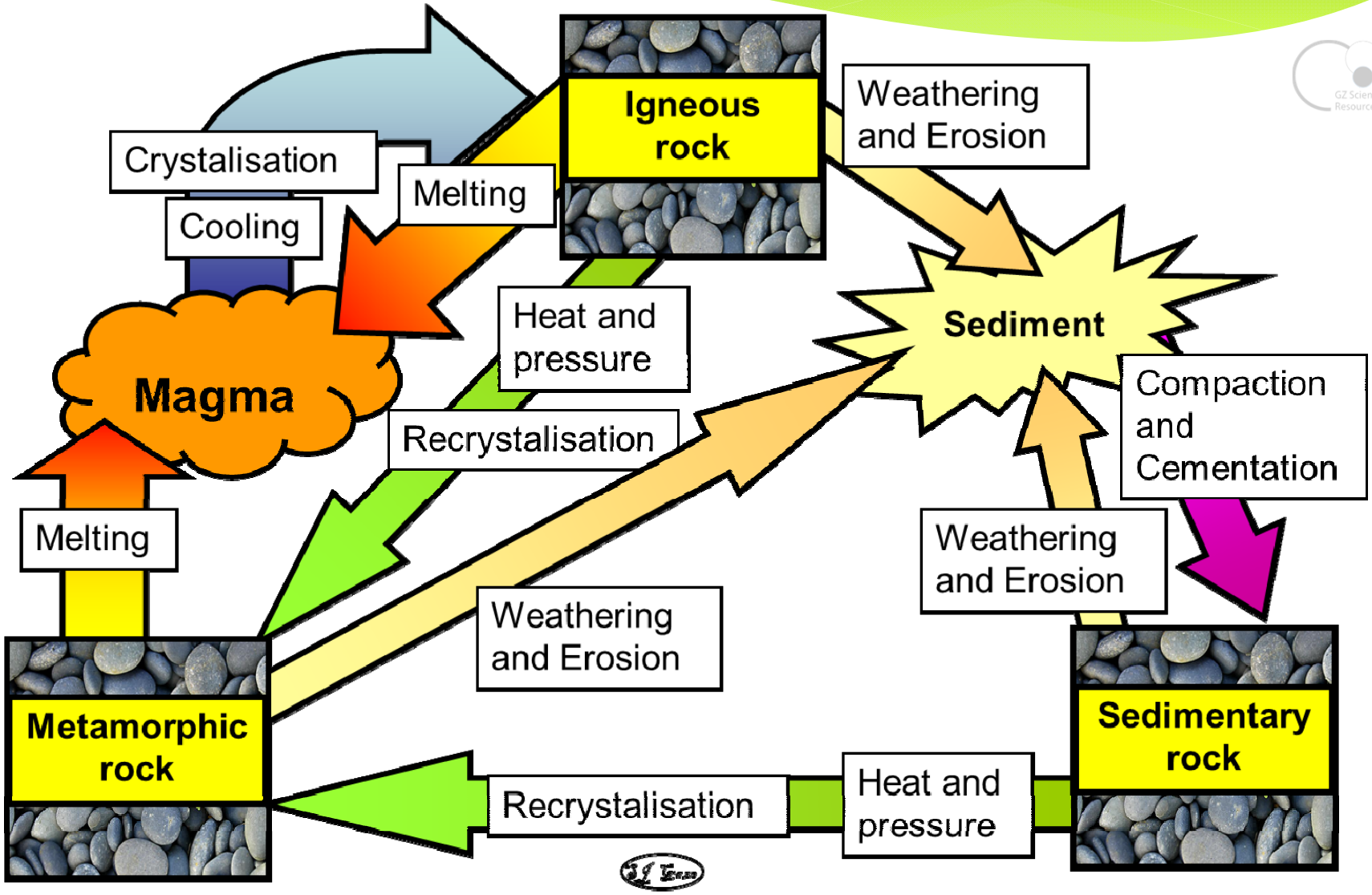


A rock key is used to identify types of rock



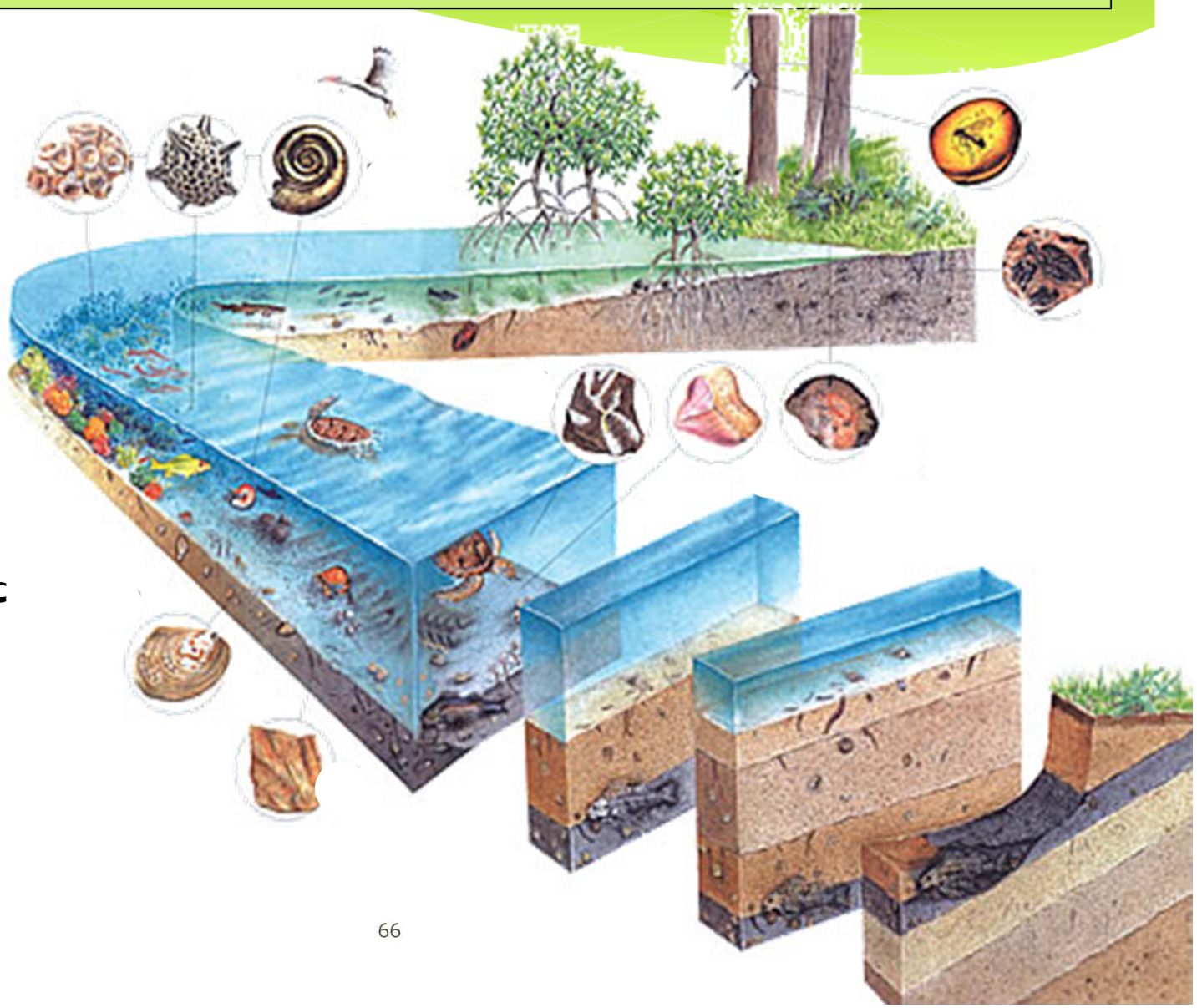
A rock key can be used to identify unknown rocks by observing the rocks physical features and its reaction to acid. Physical features include hardness, colour and presence of bands or sediments within the rock.

The rock cycle describes how rocks gradually change in form over a very long period of time

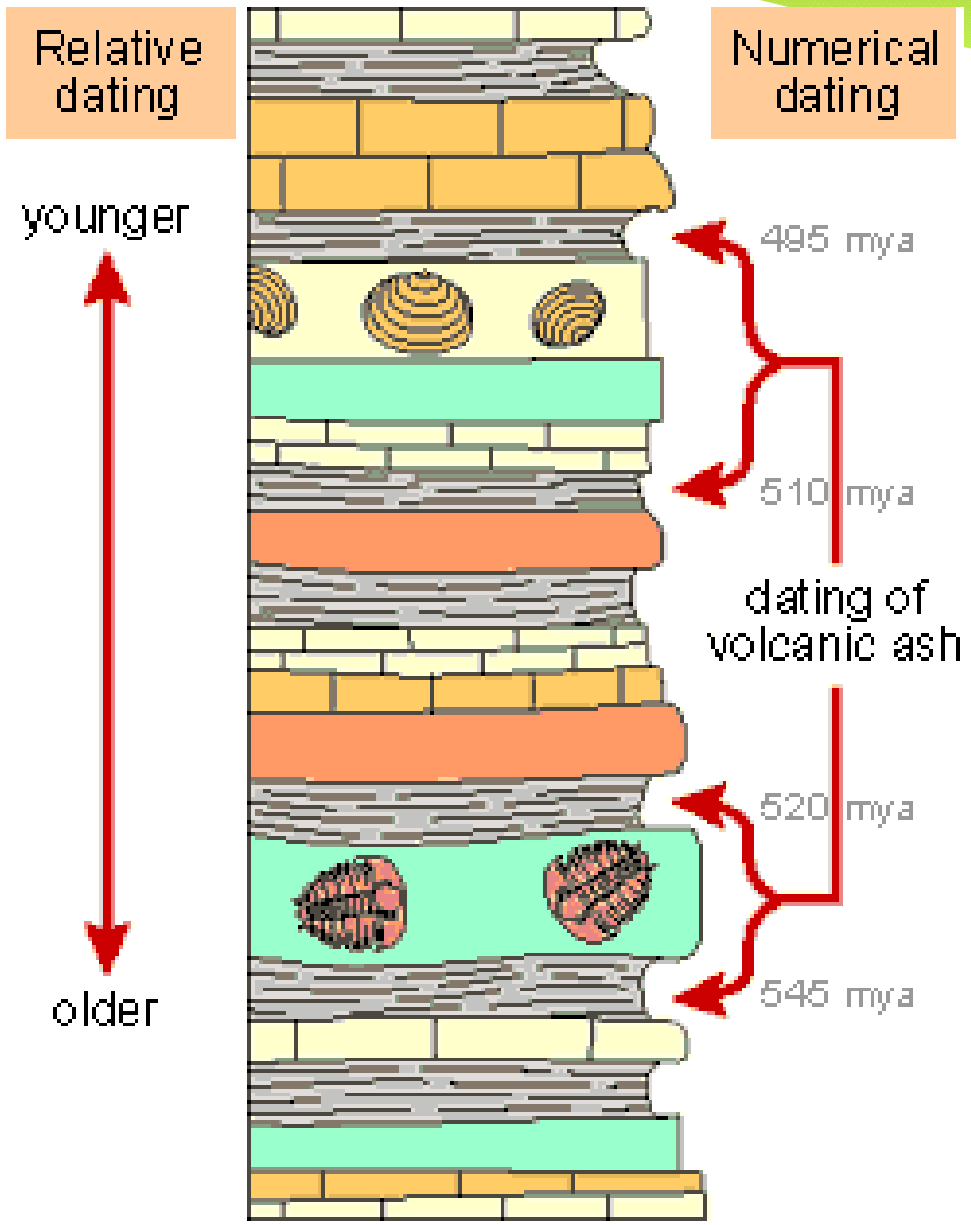


Some rocks contain fossils that are evidence for evolution

Fossils are the remains of long dead organisms that have been covered by sediments before they had a chance to decompose and are then **compressed.** Minerals from the rock material replace the organic material of the dead organism and a cast or fossil is created. **Uplift** and **erosion** of the rocks over time reveals the fossils.

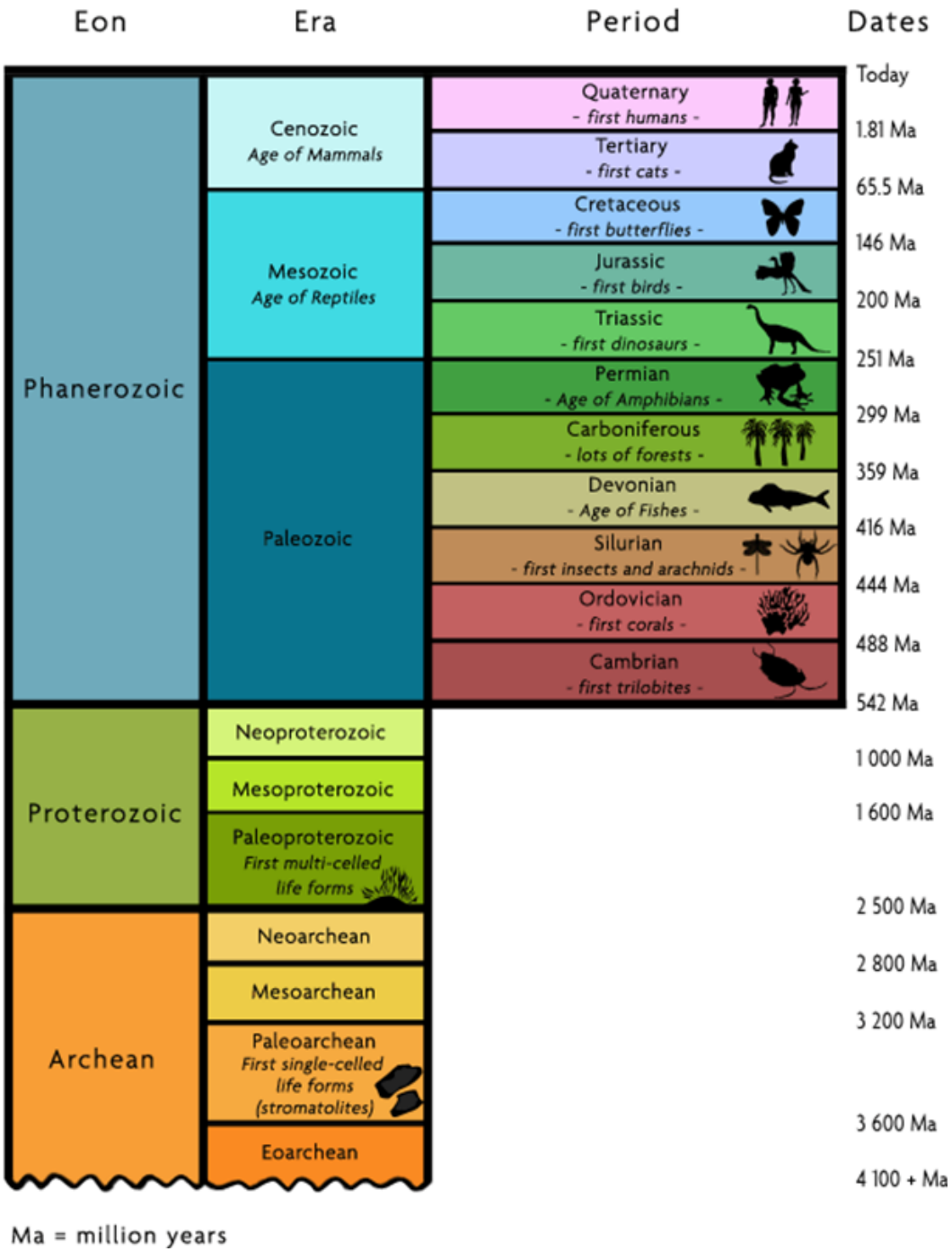


Some rocks contain fossils that are evidence for evolution



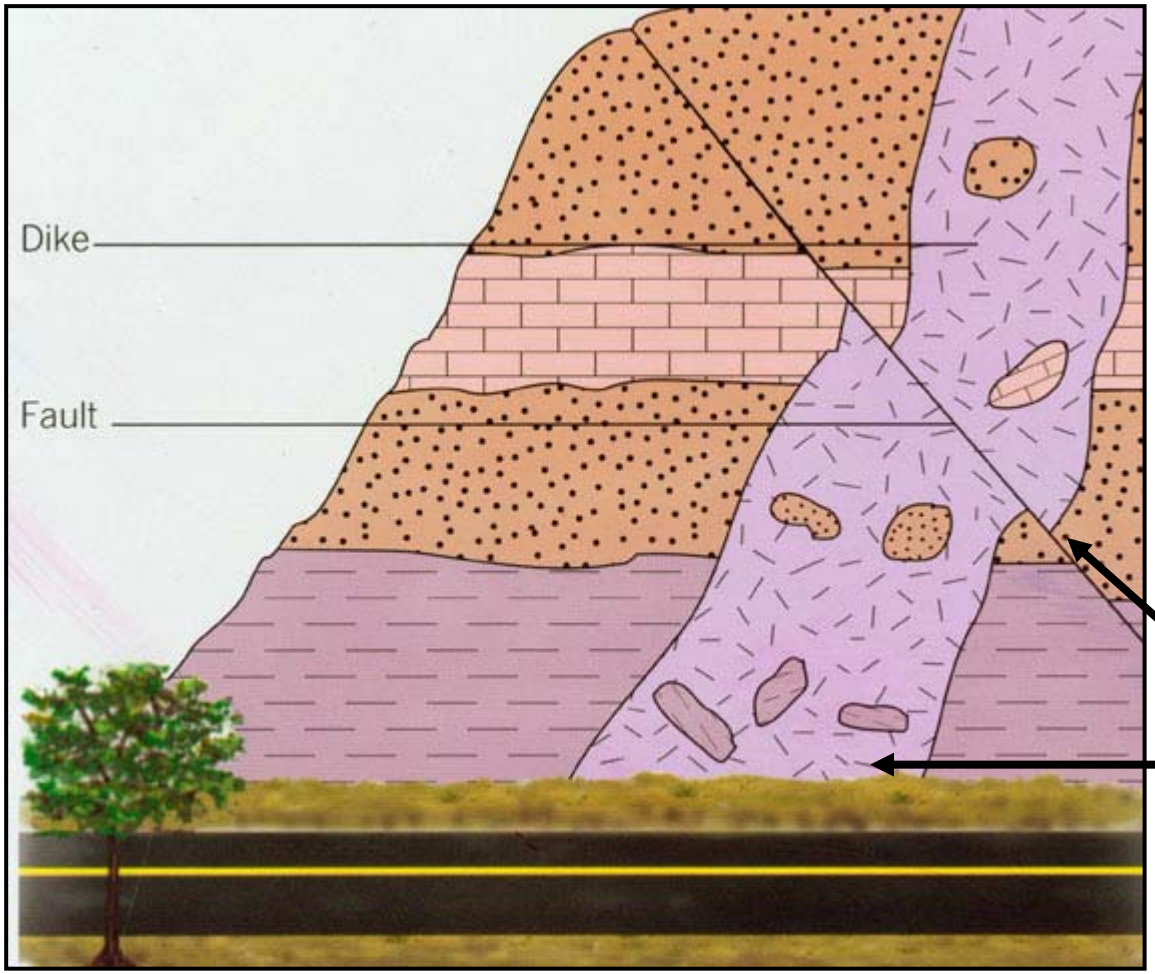
Scientists are able to date rock, called **radiometric** dating, where the rate of decay of certain radioactive elements in minerals tells us how long ago the rock was first formed. Any fossils found within that same rock can reasonably be given that same date – how long ago they lived, died and were buried by sediments. Scientists can show that different types of living organisms were present on Earth at different times in the past. In fact around 99% of all living species ever to have evolved on Earth are now extinct.

Geological time chart



Scientists have divided the 4,550 million years of Earth's history into geological periods, each defined by the type of species present. The longest period was the Precambrian. In this time only bacteria and single celled organisms were found to have existed. There is not much evidence of any remains due to geological processes and earth movement occurring during and since this time.

Newer rocks are usually found above older rocks



Earth processes cause the types and arrangement of rocks to change as well. We can look at these changes and help us understand past events.

Stratigraphic columns give a cross-section through the rock. The older rocks are to be found at the bottom. **Faults** cut through the older layers of rock. **Volcanic intrusions** are newer than the rock they push through. Types of fossils present can also help us find the age of rock types relative to others.

Weathering and Erosion shape the landscape

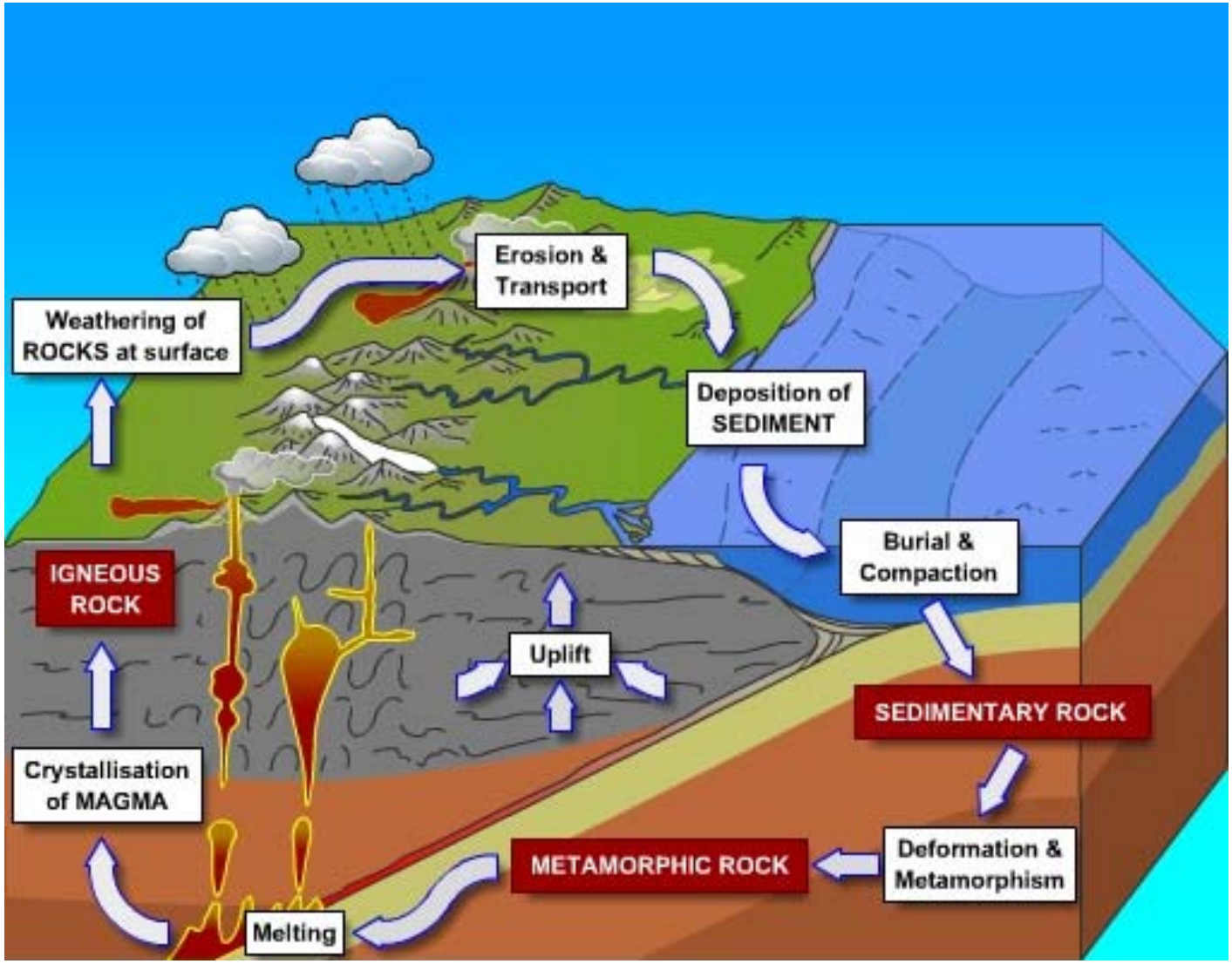
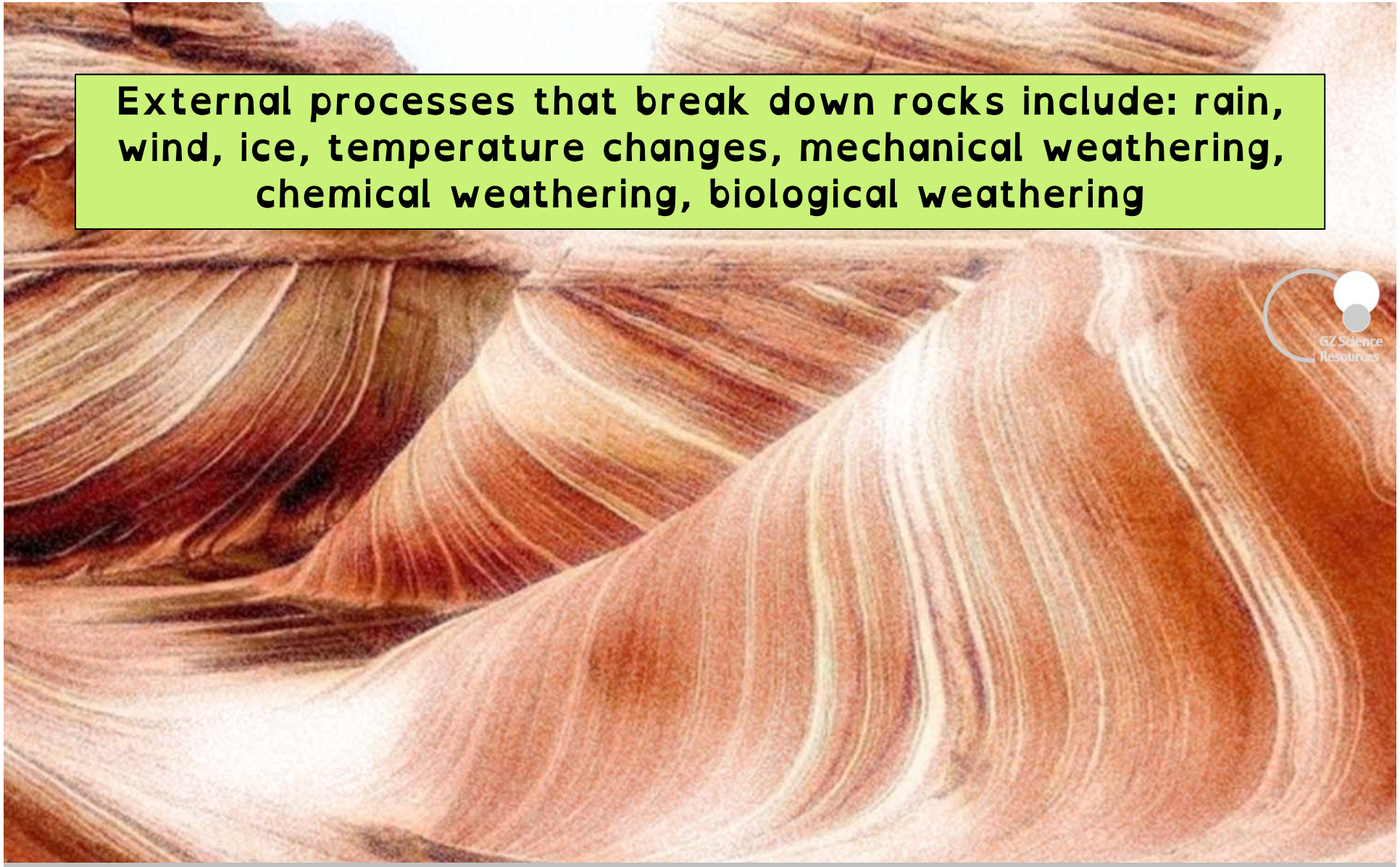


Plate tectonic movement is the **internal** force responsible for pushing land upwards and building mountains. Weathering and Erosion are the **external** forces responsible for wearing and breaking the surface features back down.



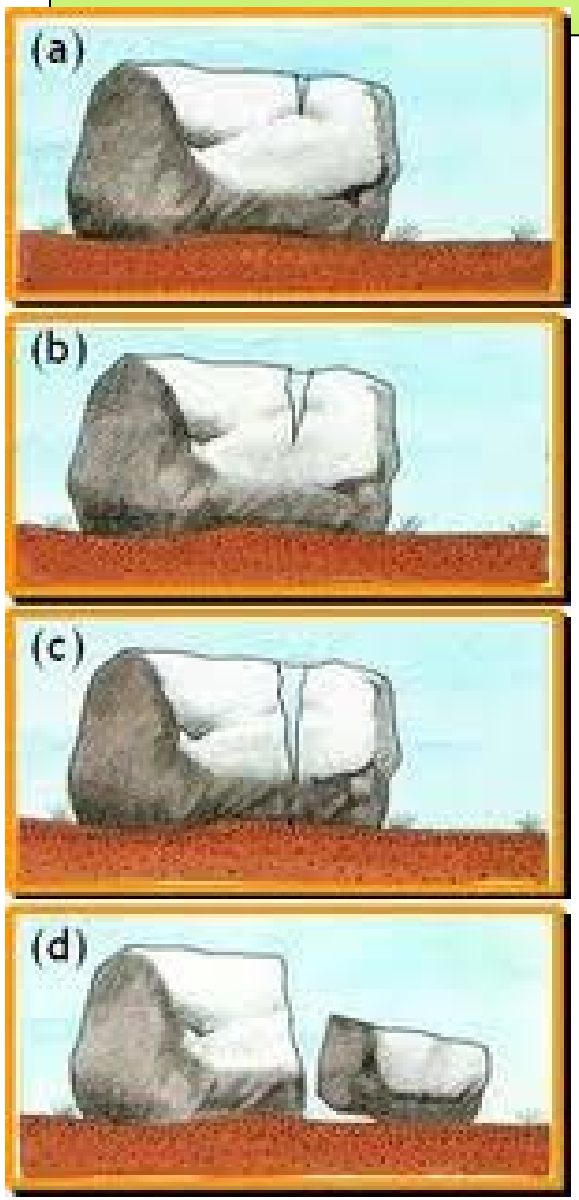
Weathering is the natural wearing down of objects by elements like water, wind and ice in the environment. **Erosion** is the process of transporting weathered material. This wearing down of objects can be either mechanical, biological or chemical.

External processes that weather rocks include: chemical weathering

Chemical weathering causes the breakdown of surface features into particles with a different chemical composition. Water can dissolve many kinds of rocks into a solution that has a different chemical makeup than the original substance.

Acid rain can rapidly dissolve calcium carbonate based rocks such as limestone and create vast networks of caves.

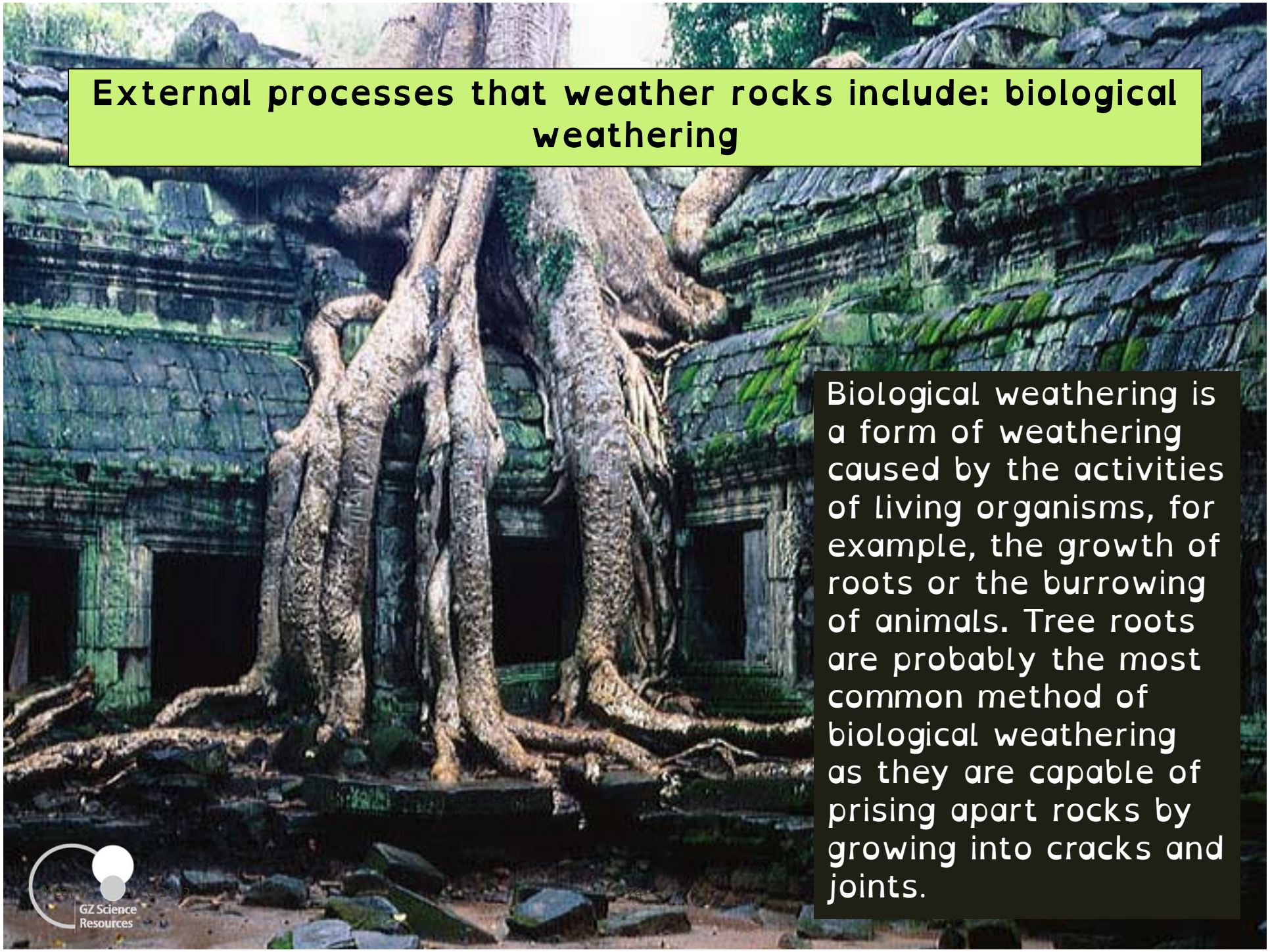
External processes that weather rocks include: mechanical weathering



Mechanical weathering is the physical breakdown of an object into smaller pieces. Changes in temperature with the freezing and thawing of water, are forces of mechanical weathering.

Water can seep into small cracks in rocks (a) and freeze when the temperature cools widening the rock (b). This process is repeated and the crack gets bigger (C) until the rock is finally spilt apart (d).

External processes that weather rocks include: biological weathering



Biological weathering is a form of weathering caused by the activities of living organisms, for example, the growth of roots or the burrowing of animals. Tree roots are probably the most common method of biological weathering as they are capable of prising apart rocks by growing into cracks and joints.

External processes that erode rocks include: rain

Rain may move soil directly if the rain falls with sufficient strength. Soil particles are moved a short distance.

Rainfall may also move soil indirectly and create gullies. As time passes small gullies are made larger and larger.

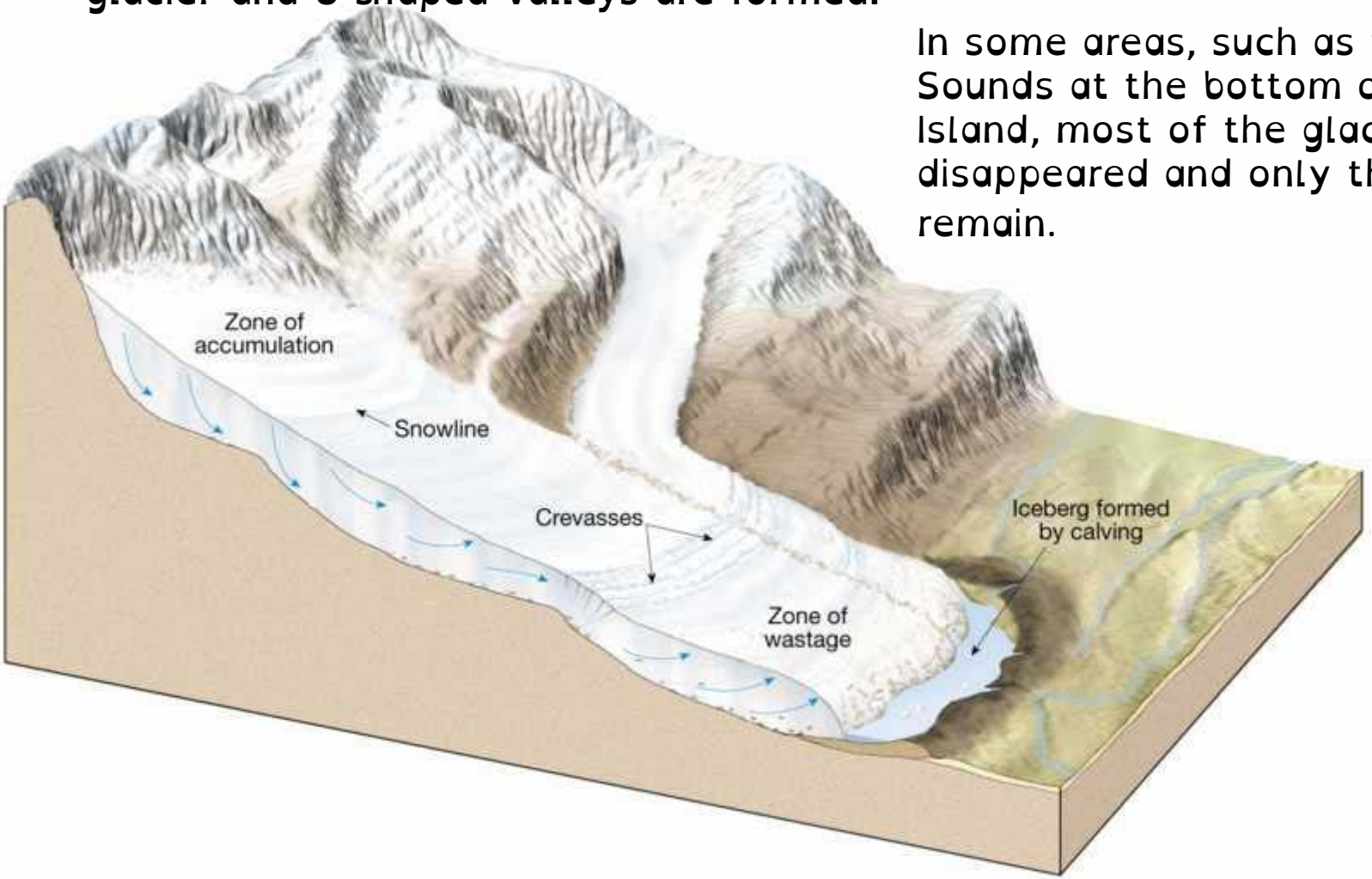
External processes that erode rocks include: wind

Sandstone rock pinnacles at Namburg National Park, Australia.
In dry areas, wind erosion can create upright columns of sedimentary rock such as sandstone. This erosion occurs over millions of years by wind, when cores of rock harder than the surrounding rocks survive above the landscape. Blast effects of sand carried by the wind then smooth the feature.

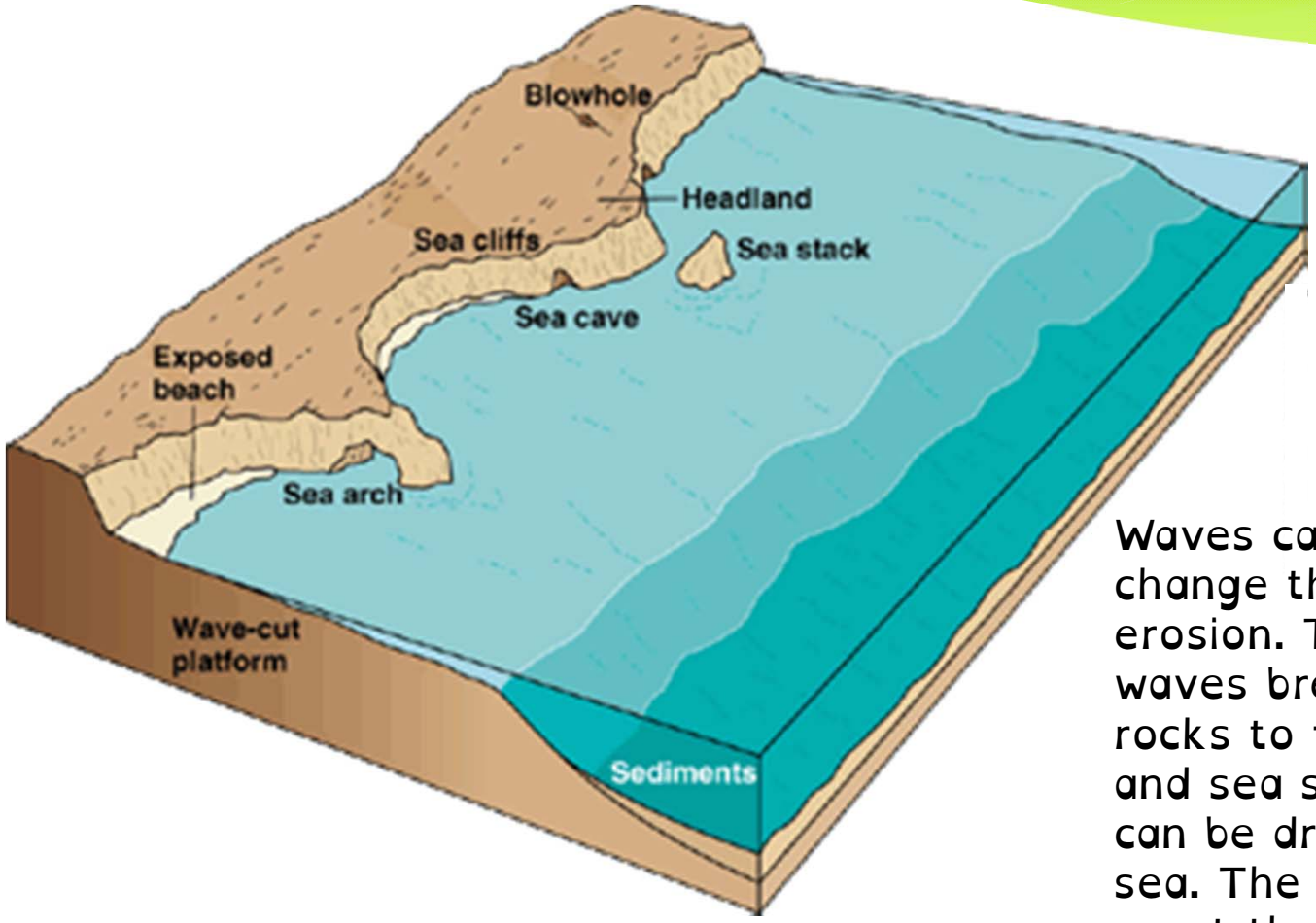
External processes that break down rocks include: ice

In high altitude or cold areas snow and ice can build up in mountains to form glaciers. The weight of the glacier and gravity cause it to move very slowly down hill. Underlying rocks are ground away by the weight of the glacier and U shaped valleys are formed.

In some areas, such as the Milford Sounds at the bottom of the South Island, most of the glaciers have disappeared and only the valleys remain.



External processes that erode rocks include: waves



Waves can shape and change the coastline due to erosion. The action of the waves breaks away the rocks to form bays, caves and sea stacks. Sediments can be dropped far out to sea. The waves also break apart the rock into smaller particles to form pebble or sandy beaches.