On the Geology of the Marlborough Sounds and the Island of Pohuenui (New Zealand)

The area surrounding Nelson is one of New Zealand's most interesting regions. It contains some of the oldest rock formations of both the country's North and South Island. The area is also home to the tectonostratigraphic terranes (fragments of major tectonic plates) that form the country's bedrock. The southernmost reaches of the Nelson region border on the Alpine Fault. This fault signals the boundary between the Pacific and the Indo-Australian Plates and had a significant part to play in the formation of the Southern Alps. The island is predominantly green and boasts fertile soil, verdant shrubland and small forests.

The Geology of New Zealand – An Overview

The illustration featured on the next page shows a contemporary tectonic outline of New Zealand in relation to the continental and oceanic plates and their movement patterns. The science of plate tectonics first emerged during the 1960s. Geologists succeeded in developing a recognized and universally accepted theory about the composition of the earth's and its movement throughout space and time. New Zealand is a perfect example of the description of the complex and dynamic development processes.

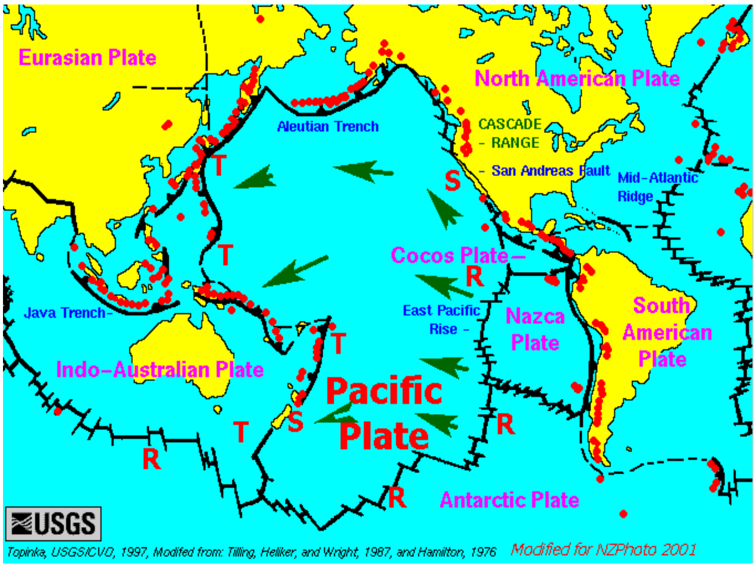
Alfred Wegener

The founder of plate tectonics (initially referred to as continental drift) was the German meteorologist, Alfred Wegener (1880 – 1930), who first published work about the field in 1911.

The actuogeological model is preceded by a period of development which lasted over several billion years. It has since been possible to trace both the basic principles and the disconcerting elements of this development model right across the world. It is broadly accepted that, approximately 850 million years ago, towards the end of Precambrian Period (the longest spanning geological era), New Zealand and its oldest geological formations were located somewhere between the Rocky Mountains and the Great Lakes on the 20th Parallel North, in what is modern-day Canada. During this time, the continents of the earth were distributed in entirely different positions, forming a supercontinent referred to by geologists as Rodinia. The component parts of Rodinia later broke away from each other before going on to reconfigure themselves in a completely different form (see below), following a movement pattern that conforms entirely to the processes described in the illustration below.

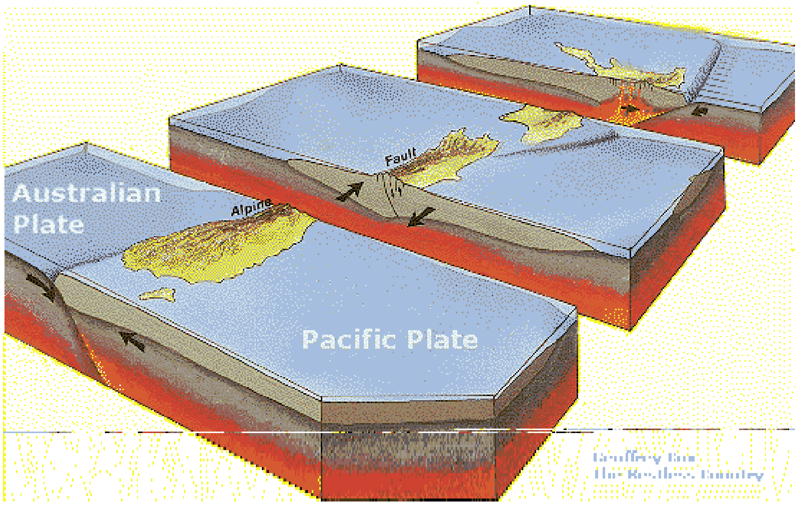
Back to New Zealand – the continental crust has a relatively low-density and therefore "swims" on top of the denser rock formations on the sea floor – the oceanic crust. Low density granite floats on top of the denser / heavier basalt. A glimpse at the graphic below shows that New Zealand effectively forms the eastern edge of the Australian plate. From the point of view of Australia – which is a very stable continental land mass – New Zealand demonstrates countless geological faults – the most significant of which can be found above sea level! Indeed, it is only due to a bulge in the earth's surface (a direct consequence of a collision between the Australian and Pacific plates), that New Zealand can rise above the ocean at all.

Compared to continental land masses such as Australia or New Guinea, New Zealand boasts a substantial amount of land mass. Much of this land mass is submerged, forming a long, thin continental shelf which is sometimes referred to as Zealandia.



The formation of this shelf can – to a large extent – be traced back to the erosion of the Australian and Antarctic massifs – some time before the Tasman Sea and Southern Ocean were formed as a result of the continents drifting apart. This once mountainous region to the east of Australia eroded to form the low-lying hills and erosion products that make up the continental base of New Zealand. The continental shelf has a considerable impact on modern-day New Zealand's economy. Due to its size, the shelf can support a large amount of fish stocks.

Due amount of volcanic activity in this region, one would perhaps expect New Zealand's North Island (which comprises – to a large extent – a volcanic plateau), to break apart, sink, and ultimately form a rift valley. Two factors are able to prevent this from happening: firstly, the force of magma, which ensures the land mass remains on the earth's surface, and secondly, the lava and solidified volcanic flue ash (ignimbrite), which fill up depressions during periods of volcanic activity.



Whenever the Pacific plate descends beneath the North Island of New Zealand, it causes the geological formations to suture together. The less dense components rise up as magma to form the region's powerful volcanoes.

The friction generated by the plates' movement causes earthquakes to form. The subduction area where the two plates ride over each other is known as the Benioff Zone. In Northern New Zealand, the source of the earthquakes (i.e. the subduction area) is positioned deeper the farther west one travels from the sinking Pacific plate.

The formation of connections between plates is particularly complicated in this region for several reasons:

1. Due to lateral movement between the plates along the Alpine Fault,
2. Because of the subduction of the Pacific Plate over the Australian Plate at the Kermadec Deep Sea Trench (North Island),
3. Because of the subduction of Pacific Plate over the Australian Plate at the Macquarie Ridge (South Island) and…
4. Because the land in the volcanic triangle around North Island has been torn apart, thus forming the edge of the East Cape.

A terrane (or, to give them their full name, tectonostratigraphic terranes) in geology is a fragment of the earth's crust which have formed on or broken off from one tectonic or continental plate and accreted (or "sutured") to crust lying on another plate. This fragment of crustal material preserves its own geologic history, which is different from that of the surrounding area. The suture zone between a terrane and the crust it attaches to is usually identifiable as a fault.

The terranes which make up the basement of New Zealand and in particularly the Nelson Region are divided into two regions, North Zealandia (or Western Province) and South Zealandia (or Eastern Province). The latter is home to the Caples Terrane. Both regions border the Median Batholith.

The Caples Terrane covers a large part of the Marlborough Sounds – from Durville Island in the east and the Charlotte Sounds in the west and down to Nelson Lake and the Alpine Fault in the south west. The geological formations of this terrane – which largely originated in the Upper Carboniferous era – consist mainly of sandstone and clay shale. Between the later Permian Era and Triassic period (256 – 227 million years B.C.) these rock formations were pushed to the ocean's surface by the Australian Plate and metamorphosed into green slate under the load of younger rock formations and increased heat.

The Physiography of the Marlborough Sound

The Marlborough Sounds and the mountain chains located directly to their south form a block of crust which inclines slightly towards the north. Directly to the east, the region borders on the Alpine Fault, a large lateral fault along which the fragments of New Zealand have so far slid some 500 km. And by "slid", we really mean an earthquake-generating rumble.

The larger valleys and sounds of this area were formed along the strike of the variously weather-resistant rock formations as well as along faults in the earth's crust (regardless of the type of rock). The slopes in this area are generally very steep. During the Ice Age – in particular, during the closing 500,000 years – profound ground frost caused the geological structures located closely to the surface to be heavily weathered. Huge amounts of rubble slid down the slopes, filling up the valley and depressions as far as sea-level. As such, it's unusual to find evidence of stones here which haven't been weathered. The larger valley structures (and the rubble and gravel that filled them) sank below sea level because the block of crust upon which the Marlborough Sounds sits sinks to the north. The largest differences in height are up to 1,600m in the south and up to 1,000m in the north.

The Formation and Rock Formations of Pohuenui Island

The geological formations that later went on to form Pohuenui Island (known as the Pelorus-Folge) were created after the Carboniferous Period, towards the end of the Paleaozoic Period. The geological formation consists of greywacke, argillaceous slate and green slate – all of which were formed by deposits of fine sand and fine mineral turbidite (from clay particles) which – as assumed above – originated through the erosion of the Australian massifs.

As well as quartz sand, greywacke also includes considerable amounts of feldspar minerals, thus proving that they are formed via the erosion of granitic rocks (or rocks similar to granite). The accumulation of sediment on Pohuenui Island - most likely originating from the Upper Carboniferous period - reached a height of approximately 10,000 m – and are therefore up to 300 million years old.

After the erosion, the geological formations folded due to a lateral compression (plate thrust). The sheer mass of this enormous amount of sediment, the folded layers were pulled deeper still into the earth's crust, causing them to heat up. The increase in temperature (combined with the high pressure) led to a recrystallization of the mineralogical composition – a process known as metamorphosis. The geologists understand enough about the both the earlier folding process and the sedimentation process (including the implications and by-products of this) in order to reconstruct them.

The geological formation of the Pelorus Fault on Pohenui (coloured purple in the graphic) is made up of a series of large dark green-coloured greywacke and black clay shale (argillite). Neither of them contains fossils, making it difficult to determine their age. The presence of fossilized Atomodesma mussels originating from the early Permian era (290-248 million years ago) in the more recent layers have lead geologists to deduce that the rock formations here originate from the Upper Carboniferous era.

More recent geological formations have not been encountered on Pohuenui Island. Geologic formations originating from the Triassic period and containing plant residues can be found in the broader surroundings. Based on these findings, geologists have deduced that a mountain-building process took place So far, however, these geologists have not been able to draw many conclusions. What happened in the Marlborough Sounds – i.e. in the Jurassic and the Cretaceous Periods – is still unknown. There are no remnants of fossils – neither stones, nor traces of fossils.

Sedimentary deposits from the Tertiary Era (65 – 1.8 million years ago) can be found towards the south west of the Marlborough Sounds, including some steeply projecting bituminous coal seams, similar to those in Nelson. Limestone and siliceous sandstone later appeared – but had already been involved in the folding processes and therefore – partly – had steep projections.

The last thing to mention is the large amount sediment generated through erosion caused during the big freeze in the Ice Age. During the glacial period 20,000 – 12,000 years ago, the world's sea level was approximately 100m lower than now. The Marlborough Sounds were a connected area of land. As the sediment that slid down the steep slopes to fill the depressions (formerly large valley structures) between North and South Island, they caused the slopes to become steeper still and expose their mantle rock. Around the Marlborough Sounds, the crust continues to sink towards the north even now. This, combined with the effects of global warming and rising sea levels, means that Pohuenui Island will gradually get smaller over the course of the next few centuries.

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