Helen is a SEISMOLOGIST

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Helen Anderson – Seismologist

When Helen Anderson's fifth form science teacher told her she would be a research scientist one day, Helen did not believe her. She planned on being a school guidance counsellor. But as Helen grew up she became more and more fascinated by the Earth and how it moves beneath and around us. As she found out about how it cracks, slips, slides, shakes and erupts she had more questions she wanted to find answers to.

Helen Anderson, seismologist, on Franz Josef Glacier
Photo – Alex Harris

Helen always loved a challenge, finding answers to puzzles and joining in the lively discussions her family had about things happening in the world. As she grew up in Dunedin her family really supported her and encouraged her to take advantage of every learning opportunity that was available to her.

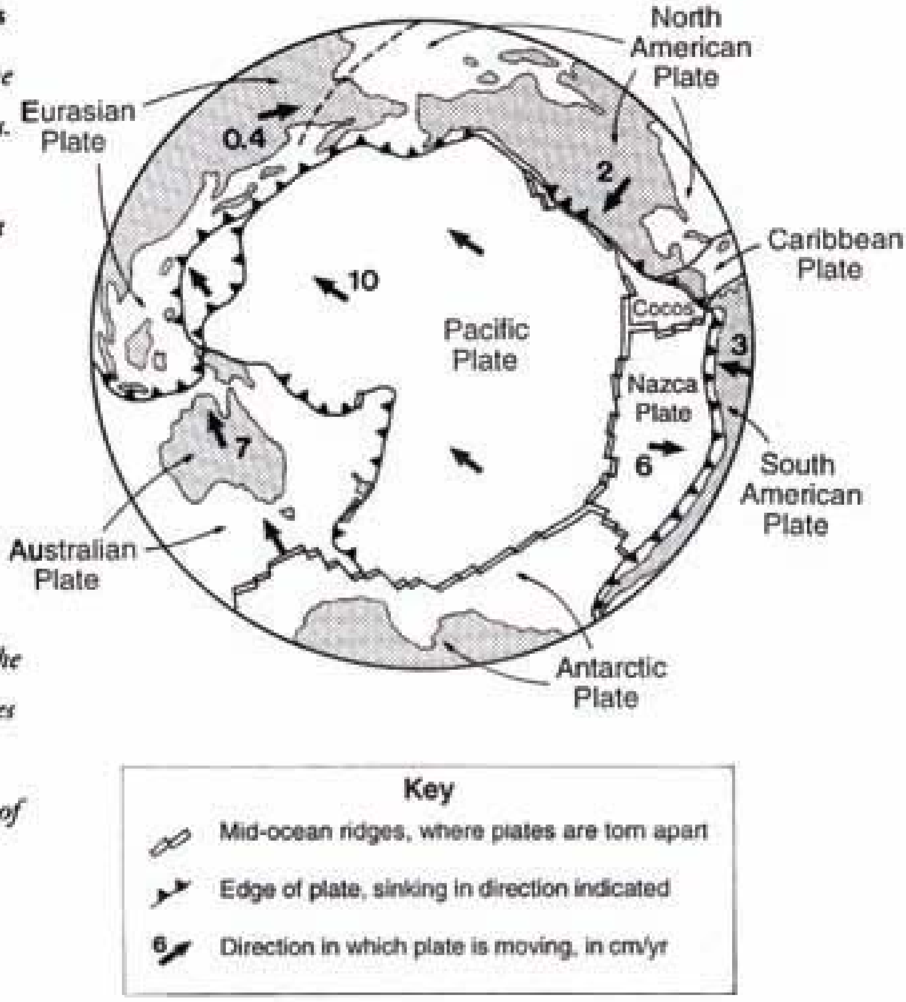
When she was twelve, Helen spent six months in hospital with asthma. Her intermediate school teacher, Miss Wilson, sent her interesting projects to do and Helen's father gave her a book – *The World Beneath the Oceans* to read. She was fascinated with the hand-drawn pictures showing what scientists thought about why the outer layer or plates of the Earth moved and caused earthquakes. She read about volcanic eruptions, how mountain ranges formed and broke down, and how gas and oil were made deep inside Earth's surface. Although Helen read the book many times it was not until she went to university that she learned more about the movements of the Earth's surface.

Helen's daughter reading the same, now dog-eared, book
Photo – Helen Anderson

The Earth's moving plates

The cold brittle surface of the Earth is fractured into plates. Each plate moves, drawn across the surface like a great carpet by whichever edge is being pulled back into the Earth most strongly by the force of gravity. The most rapidly moving plate is the Pacific plate.

The majority of the Earth's earthquakes happen where the plates collide. Most volcanoes also erupt near plate boundaries, either as chains of undersea volcanoes or towering cones on land.

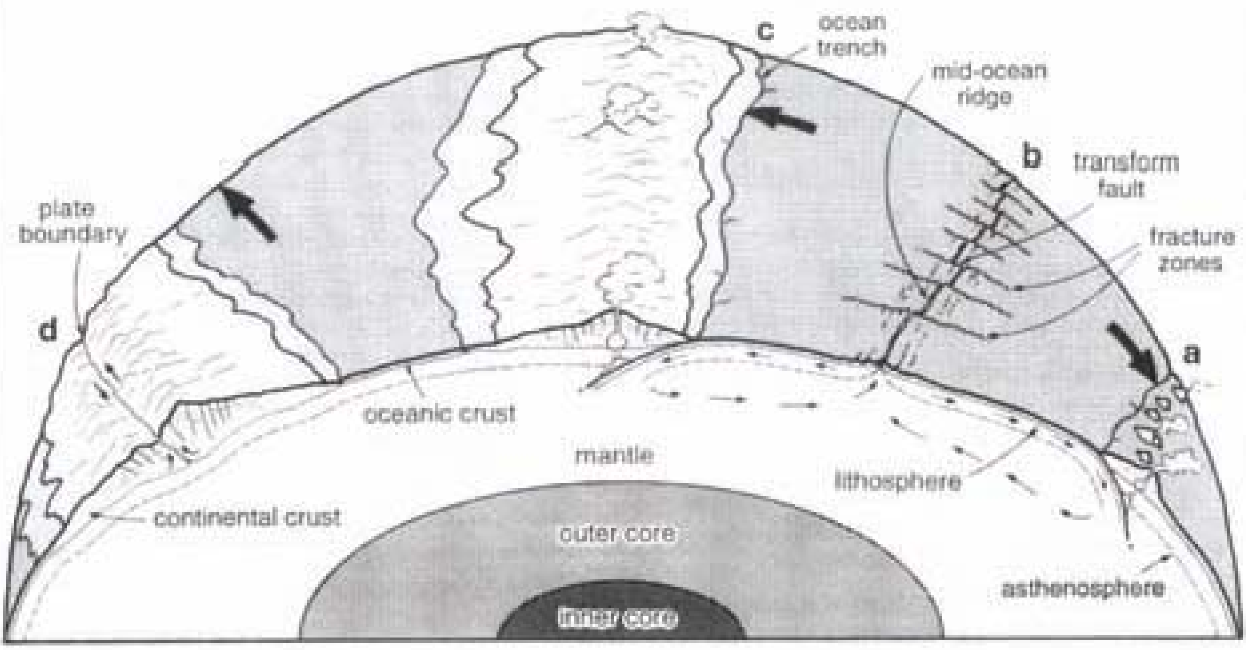


Scientists, geographers and explorers have been investigating and gathering clues for many years about the shape and position of the great continents and oceans on Earth. Some people had noticed how certain coast lines of different continents almost matched each other, others noticed that similar fossils and rocks were found in the west coast of Africa and the east coast of South America.

All these ideas, and his own study, convinced German scientist Alfred Wegener[1] that the continents were drifting across the surface of the Earth, and ploughing through the oceans. He wrote a book explaining his ideas and many people ridiculed his explanations, asking: "How could solid land masses move over solid ocean beds?" It was not until the 1960s that

[1] *Alfred Wegener's first book was published in 1915 but it appears that the first English translation was not published until 1924*

an answer was found that allowed his ideas about continental drift to become accepted. Great undersea ridges were discovered and scientists figured out that the ridges were formed by new magma forced from deep inside the Earth. At other places the ocean floor is being pulled back down inside the Earth. The new model of moving plates provided explanations for observations by many scientists over many years as ideas about plate tectonics became accepted.

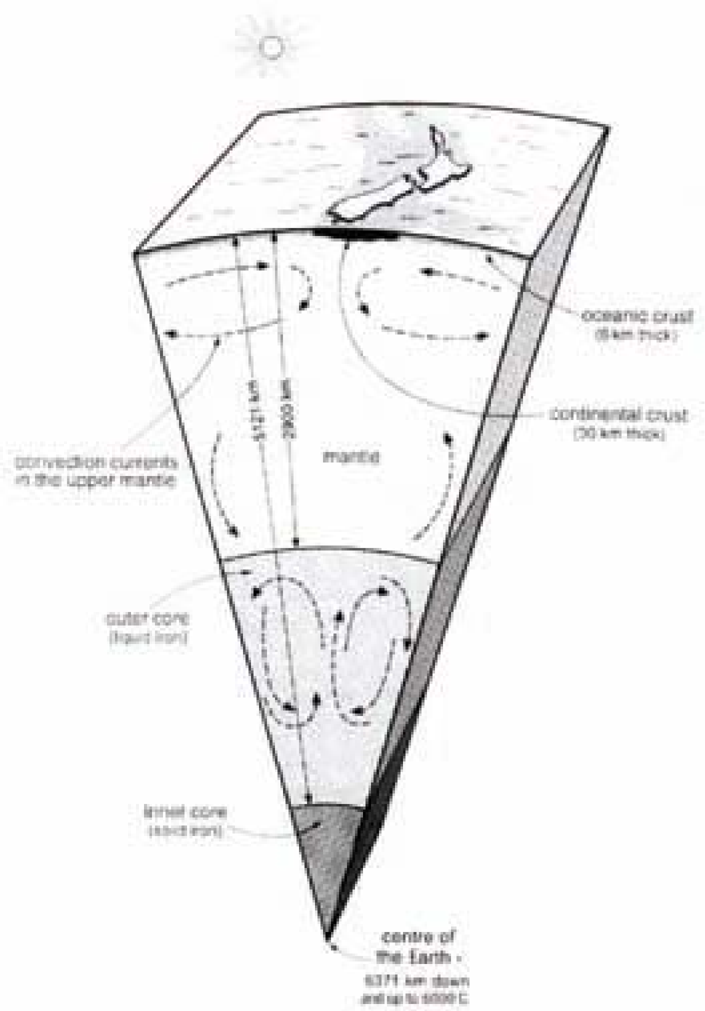


How the plates shape our planet's surface

The cold and heavy plate edges sink into the warmer and softer material below (plate boundaries a and c), pulling the rest of the plate across the globe after them and tearing the crust apart at mid-ocean ridges (plate boundary b). This tearing allows magma to rise up from the mantle beneath to fill the gap left by the moving plate.

Volcanoes can be created when two plates collide and molten rock rises from the sinking plate (plate boundaries a and c).When two plates carrying continental material collide, large mountains are forced upwards. In the case shown here (d) the mountains are also being pushed in two different directions along a fault. In the same way New Zealand's South Island is being drawn in two along the Alpine Fault at the same time as the area continues to be squeezed, buckling up the Southern Alps.

Imagine the Earth is like a fruit. It has a stone in the centre called the core, a layer around that is called the mantle and the skin like a crust. The Earth's core though, is made up of two layers – a solid inner core with temperatures as high as 6000 degrees Celsius (°C) and a molten outer core of liquid-like material. The mantle is lighter than the core, with temperatures between 1000—4000 degrees °C. It is covered with the skin-like crust and is divided into many huge pieces called plates. These are like huge jigsaw pieces and is the crust that we live on. The plates are moved around by the slow convection of the material in the mantle. Very slow movements of the plates on Earth are occurring all the time; fast movements are the ones we feel as earthquakes!



The layers of the Earth

A slice of the Earth showing its various layers of crust, mantle and core. Note the convection currents in the upper mantle, responsible for Earth's continually active surface, and those in the inner core which, influenced by the Earth's spin, create our planet's magnetic field.

When Helen was in the senior physics class at high school, she realised she wanted to go to university. She wanted to study, to find out more and hunt for answers to her many questions. A good friend suggested she take geology (the study of the origin, composition and structure of the Earth) and she loved it – although her Dad, at first, told her "You can't, it's a man's world!" For three years, at the University of Otago, she learned all about the structure of the Earth and how it used to be; about minerals and rocks and how they were formed. She moved to the University of Auckland for her final year so she could study geophysics, the study that uses physics to examine the physical properties of the Earth. It includes seismology, the study of earthquakes.

Helen studying seismograms which record earthquakes. Photo – John Nicholson (Reproduced with permission from The Evening Post, June 17th, 1989)

Now that Helen knew the answers to some of her questions, she focused her studies on how the Earth moves when seismic pressure and energy builds up in and under the crust until it reaches breaking point and has to go somewhere. She found out that the rock in the crust breaks and the energy is released as a series of waves that we feel as an earthquake.

A caramel bar covered in chocolate can be used to model some of the ways that the earth's crust deforms. If you stretch the bar, cracks appear in its surface. These cracks are like the fault that was created by the Edgecumbe earthquake. The earthquake was caused by the stretching of the Bay of Plenty region.

Photos – Linda Chronis

If you compress the bar from the ends, the layers crumple and pile up on top of each other. The Southern Alps have been created in a similar way to the mountain you create in the middle of the bar.

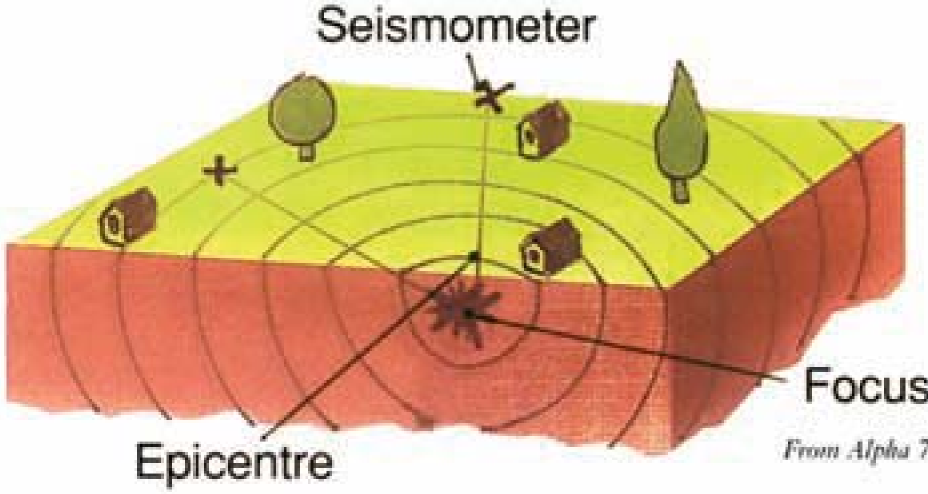
Nearly all earthquakes happen at the edges of the Earth's plates. New Zealand is the meeting place for two major plates, the Pacific Plate and the Australian Plate. These plates are moving in different directions so we get many earthquakes. Earthquake aftershocks are the movements after an earthquake as the Earth readjusts itself to the change in position.

If you push on the two ends and let one half of the bar slide below the other half, you create a situation much like exists along the east coast of the North Island. There the floor of the Pacific Ocean is grinding beneath the North Island.

Photo – Linda Chronis

In her final year at Auckland University Helen had to decide whether to do a PhD degree or get a job. The decision was made easier for her when she was offered a position in the Geophysics Section of the Department of Scientific and Industrial Research (DSIR). She enjoyed studying the sedimentary layers under the earth that provided important information for coal mining and oil exploration.

After four years Helen was awarded a scholarship to study for a PhD at Cambridge University, in England. She studied the very dense rock that was pushed up when France and Spain were squeezed together in past ages, and learned about the movement of forces between the giant African Plate and the Eurasian Plate. She traced the effects of thirty years of

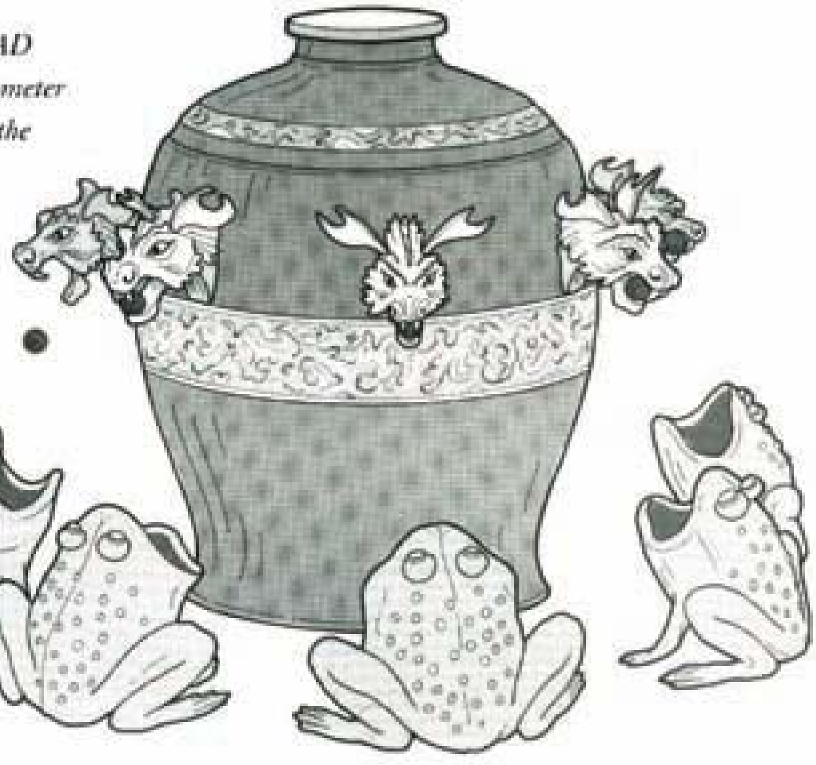


From Alpha 79 Waiting for the Big One

An earthquake sets up shock waves in the Earth, which radiate away from its focus underground. Plotting the direction from which the waves reach two or more seismographs enables us to pinpoint the epicentre, the point on the ground surface vertically above the focus.

earthquakes in the area and discovered a smaller microplate caught between them. This became the topic for her thesis. She had to set up and get readings from seismometers, (instruments that measure earthquake movements), gather records from them and get records from other places all over the world.

Helen setting up seismometers in the Southern Alps
Photo – Dr Nigel Barlow (AgResearch)



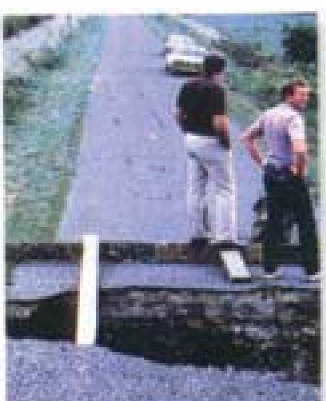
Zhang Heng's seismoscope (AD 132) a simple form of seismometer that attempted to determine the direction from which an earthquake arrived.

From Alpha 60 Edgecumbe

The Edgecumbe Earthquake

On 2 March 1987 at 1:42 p.m. a major earthquake sent shock waves across the Bay of Plenty. Centred close to Edgecumbe, a rural dairy town, there was a strong foreshock seven minutes before the main earthquake now known to have measured 6.6 on the Richter Scale. The land was moving like ocean waves: a whole large dam was moved downstream 200 millimetres, a train engine tipped over, a road cracked open two metres wide and four metres deep and transformers were torn from their positions. Helen, who had returned to New Zealand, spent some time studying the effects of this quake and was there during many of the aftershocks that continued for weeks.

(Refer to Alpha No 60 Edgecumbe.)



From Alpha 60 Edgecumbe

From Alpha 60 Edgecumbe

In the 1990's Helen studied and worked in Santa Cruz, California for a year, studying the San Francisco and Macquarie Island earthquakes. She became part of an international network of seismologists who share information all over the world. This is very important so trends and patterns can be identified and provide more accurate information about when and where earthquakes might occur in the future.

Helen installing seismometers in a tunnel in the Cromwell Gorge
Photo – Dr John Haines (Geological and Nuclear Sciences)

After 16 years' research with DSIR and the Institute of Geological and Nuclear Sciences, Helen was appointed Director of Earth and Ocean Science Research. It was here she carried out a huge project called the Southern Alps Passive Seismic Experiment. Earthquakes in the South Island are not evenly distributed and scientists wanted to find out why some areas in the Alps have few or no earthquakes.

Seismologists catch up with lunch near Rotorua
Photo – Dr Russell Robinson (Geological and Nuclear Sciences)

Forty extra recorders were put in place throughout the South Island – 26 state-of-the-art recording instruments from the USA and 14 from New Zealand – to record earth movements. This involved flying helicopters and driving off the beaten tracks from Fiordland to Nelson Lakes. It meant driving around and locating suitable sites, which had to be on hard rock, with enough sun for the solar panels providing power for the instruments. It was a huge experiment with the South Island set up like a big laboratory and many scientists were involved.

In the middle of this study a big earthquake of magnitude 6.1 happened. This was wonderful for the team – they got the best data coverage possible with all the instruments working!

Seismologists flying high in the Southern Alps setting up seismometers
Photo – Dr Nigel Barlow (AgResearch)

From this work scientists were able to find out that there was a more even spread of earthquakes in the area than previously thought. The information collected will help explain what is happening in other parts of the world including California.

Just over three years ago Helen was chosen for the important job of Chief Scientific Advisor for the Ministry of Research, Science and Technology. Now she works only a tiny bit on her own research. Mostly, she has to be generalist. If a science issue, such as cloning, comes up she needs to get expert opinions, decide what is important for Government and help ministers with information. One of Helen's challenges is to understand the role that science has in improving the economic health of New Zealand. She makes sure that policies that are developed will work for scientists and she decides how they will contribute to these policies.

Helen is responsible for all international science and technology relationships, so with this job comes lots of travel. In one year she has been to England, Sweden, Chile, Argentina, Brazil, France, Malaysia and Antarctica. Travelling is exciting and Helen loves her job but she also loves to be home with her family at night.

Helen and her husband, Michael, have two children, James who is 15 years old and Saskia who is 12. James has special needs but the family are able to make sure he is well cared for night and day.

Helen and family rock-pooling at Doctor's Point
Photo – Bill Nichol Photography Ltd

They enjoy regular trips away at the weekends and longer holidays together. Often they travel to the family home at Wanaka where they camp and fish with their grandfather, and they enjoy skiing in the winter. Saskia was lucky enough to be able to travel to London and Stockholm with her mother for a holiday recently, while other family members looked after James. Helen is not really keen on travelling but it is part of the job and the children love hearing about her experiences when she gets home. They can even have bedtime stories about what their mum did in Antarctica last week!

Helen at the edge of the sea-ice with friends and penguins, Antarctica
Photo – John Spittal (Land Information New Zealand)

On the bookshelf at home Helen still has that book her father gave her as a child, the one that she read and re-read about the Earth's surface. She's glad to have found so many answers to her questions and knows there are many more things to find out about and learn.

And what does her father think of her now? Dad is very proud of his daughter Helen. He is continually surprised and excited about things that have happened and things that are likely to happen next in Helen's busy life.

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