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My main field trip for 2005 was disguised as a holiday. My wife is interested in botanical gardens rather than geology, but, provided the itinerary was fairly balanced, everyone would hopefully be happy. The month of March in NZ is the end of their Summer; we were expecting the climate to be dry and warm, but not hot - in fact, good field trip weather.

The mention of NZ to other members of the Society brought forth offers to lend useful information as well as reminiscences of interesting geological sites. With a bit of judicious pre-planning I thought we could begin in Auckland, fit in a number of key sites in both islands and manage to arrive in Christchurch in the South Island in time to get the 'plane back. My guide was to be "The Reed Field Guide to NZ Geology" by Jocelyn Thornton (2003), which proved to be absolutely indispensable as both a textbook and as a means of identifying key sites to visit en route.

The Field Guide explains the phases in the evolution of NZ from the accretion of sediments at the edge of Gondwanaland through to the separation of NZ from Australia about 85Ma, when the New Zealanders got a "place of their own", to the arrival of the ice in the Quaternary. The various upheavals are known by Maori names such as the Tuhua, Rangitata and Kaikoura orogenies.

NZ's location on a tectonic plate boundary, where the Pacific Plate is subducting under the Indo-Australian Plate east of the North Island and the Indo-Australian Plate is subducting under the Pacific Plate to the south-west of the South Island creating a transform fault, called the Alpine Fault, is fascinating. The resulting faulting and subduction zone volcanics together with rocks dating back to the Cambrian make NZ a country well worth exploring.

We had a long-standing invitation to visit friends in Auckland in the North Island, where we began our field trip, I mean holiday. The urban landscape of Auckland is punctuated by extinct volcanoes. It shares the area with the Auckland volcanic field, a collection of 49 relatively small monogenetic volcanoes, mostly less than 150m in height, having a cumulative eruption volume of around 4.1 km^3. The eruptions are thought to have started about 150,000 years ago and the field is considered to be still active.

Our drive up to the top of Mount Eden was rewarded by a view into its grass-covered crater as well as the sight of One Tree Hill, another extinct volcano and famous Auckland landmark, in the distance. The view in the seaward direction was to Mount Rangitoto, an island formed from a shield volcano, which last erupted about 600 years ago. Rangitoto is by far the largest volcano in the Auckland volcanic field and has an eruption volume of about 2 km^3.

Rangitoto is about 260 metres high and is accessible by a 35-minute ferry crossing from Auckland harbour; the island is uninhabited and a popular place to walk. The hike to the top took us a couple of hours, with ample stops to view things on the way, and we obtained spectacular views from the summit. The narrow trail winds through areas of rough, rocky rubble of basaltic aa-type lava, which are interspersed with areas where trees and vegetation have taken hold. The most dominant tree is the pohutukawa and Rangitoto has the largest remaining pohutukawa forest in NZ. The island is managed by the NZ Department of Conservation (DOC), who have erected display boards explaining the island's geology and the development of its flora. The porous basaltic scoria around the cone are grey, or red in colour where oxidised, and the lava flows have produced some interesting tunnels, which are still accessible despite encroaching vegetation.

Our journey southward from Auckland took us to Rotorua, which is part of the Taupo Volcanic Zone. The violent and unexpected eruption of nearby Mount Tarawera in the early hours of the 10th June 1886, which forms part of the frequently-repeated history of the area, was one of New Zealand's greatest natural disasters. The publicity material showing the 5km rift in the mountain with well-exposed deposits of red and black basaltic scoria contrasting with the older grey-white rhyolite lavas from an earlier eruption creates an urge to go there and see it. Unfortunately, contrary to the Reed Field Guide and the local website, there is no longer any direct public access to the area around Mount Tarawera. Access is now virtually only with a half-day organised tour of the area by 4WD vehicle to get close to the summit, which is probably one of the most interesting geological features in the area. Not being able to fit that tour in was a big disappointment, but NZ has many other geological highlights on show.

The routes from Rotorua to Taupo are billed as "Thermal Highways" for tourism purposes. The area contains some interesting volcanic valleys with colourful pools revealing a range of deposits created from minerals dissolved deep underground by the geothermal springs. One site had a geyser, which erupts daily at 10.15 a.m. (Daylight Saving Time). Nature is not geared to such precision, so it was aided by 300 grams of soap thrown into the orifice to break the surface tension of the water below and, as promised, the geyser spouted on schedule.

Next stop was the Tongariro National Park, which contains three active andesite volcanoes: Tongariro (1,767m), Ngauruhoe (2,287m) and Ruapehu (2,797m); these dominate the southern end of the Taupo Volcanic Zone. The area of this volcanic plateau contains a track for one of the most famous one-day hikes in NZ, called the "Tongariro Crossing".

For the motorised, access to the central area of the park is by a road leading up to the Whakapapa Village at 1,630 metres, where chairlifts operating during the skiing season lead further upwards towards the summit of Mount Ruapehu, which last erupted in 1997. We took a coffee stop on the drive up at the stately but almost deserted Grand Chateau Hotel. Contrary to our expectation, morning refreshments proved to be cheaper than at some tourist cafés in Bath.

I needed something of geological interest on the route south to Wellington. The Manawatu gorge is about 10 km long and is just east of Palmerston North. The river in the gorge flows westward to the Tasman Sea from one side of the mountain range to the other rather than from a divide, as do most rivers. According to the local geological notes, a wedge of basement greywacke, thought to be mainly of Triassic age, has been slowly thrust upward between two major faults over the last million years and the river has continually cut down through the rising mountain range to create the present-day gorge. This impressive gorge is shared by the river, the road and a railway track, and having driven into the gorge there is virtually nowhere to stop until the other end is reached; it was worth a slight detour.

We made good progress towards Wellington and there was time for a diversion over to the west coast just north of Wellington to visit a totally deserted Titahi Bay. The rocks of greywacke sandstone around the bay and below the high water level were cracked and eroded forming the classic rusty box work pattern, (*photograph 1*).

Photograph 1: Weathered greywacke at Titahi Bay near Wellington.

I made a mental note to learn more about the structure of greywacke and how it breaks down when it weathers.

Wellington, NZ's capital city, has its faults: the Wellington Fault runs near the edge of the harbour; the Ohariu Fault lies to the west of the city, and the Wairarapu Fault to the east. The last really major earthquake in Wellington was in 1855 when the Wairarapu Fault moved. The Modified Mercalli Intensity Scale (MM) is popular in NZ as a measure of the destructiveness caused by ground movement at a particular place. The 1855 quake, which was pre-Richter and the modern seismograph, is assessed as MM10 in Wellington, or magnitude 8 on the Richter Scale; that level would destroy most masonry structures with their foundations.

We 'took the tour' around the NZ Parliament Building, which is 400m from the line of the Wellington Fault, and were taken to the basement to view the earthquake proofing. The building is supported on strengthened foundations by 417 isolator pads made of rubber, lead and steel. The system is designed to enable the building to withstand an earthquake in the range MM9 to MM10, where the expected lateral movement at the base of the building would be 200 to 450mm. To the layman, it looked like a building-sized version of the anti-vibration mountings used in cars to isolate the engine from the chassis.

Later that day, a drive around the coast south of Wellington revealed even more formations of greywacke sandstone eroded by the sea into interesting shapes. I was aiming for an outcrop called the Red Rocks, where there are interesting features such iron-coloured mudstones and pillow lavas, which would provide some variety from the greywacke. As we approached, the made-up road ended and we were into 4WD territory. It would need a 2-km trek by foot each way to get there and it was getting late. One irony of geology always seems to be that the more interesting the site, the more inaccessible it is.

The following day we dropped off the rental car at the ferry terminal and took the Lynx ferry from a cold and damp Wellington to a sunny and warm Picton in the South Island, where another rental car was waiting for us. The coastal route to Nelson along Queen Charlotte Drive is beautiful. Some of the oldest rocks in NZ are in the northwest of the South Island. The problem is one of what is reasonably accessible with a limited amount of time. Not far from Nelson is Dun Mountain, a large outcrop of the mineral olivine, and which gave rise to the rock being named dunite. Further study of the map revealed that access to that mountain required a long hike to get there, so that option faded.

The start of the Abel Tasman National Park with its protected coastline is a couple of hours drive from Nelson. By car it is only possible to drive around part of the periphery, although that proved rather interesting. We drove north from Nelson in the direction of Takaka. The route westward to Upper Takaka is a winding mountain-type road with spectacular scenery. The Field Guide mentions the approach to the Ngarua caves and we stopped to check out the nearby limestone outcrop and admire the karst landscape with the water-worn marble outcrops in the hills. North of Takaka I once again followed the Field Guide to try to locate an overgrown outcrop showing the bed-by-bed interfingering of Onekaka Schist and granite. After a bit of effort in clearing some covering vegetation an area of granite became visible. Clearly, this outcrop had not been given any of the benefits of RIGS status. The day was rapidly passing by so we drove east along the north coast of the park to visit the Abel Tasman Memorial in Golden Bay before returning to Nelson. Abel Tasman (1603-1659), a Dutch explorer, discovered NZ in December 1642 and the memorial marks the point where he first came ashore.

The route westward from Nelson the following day led through the Buller Gorge to Westport and Cape Foulwind where, below the cliffs, there is the unusual sight of granite boulders around 20 to 50 cm or so in size strung out in lines almost at right angles to the coast like a miniature natural breakwater. The boulders of Devonian granite rest along the edge of exposed sedimentary layers from the Eocene about 10 cm or so thick, (p*hotograph 2*). The beach was totally deserted as I picked my way amongst the boulders; like many geological sights, there are no signposts and one has to know where to go or have a good Field Guide. Just along the coast is a seal colony, which is the main attraction for non-geologists.

Photograph 2: Cape Foulwind - Granite boulders on Eocene sedimentary layers

Further south on the road to Greymouth are the Pancake Rocks at Punakaiki. It is a popular, well-maintained site operated by the DOC. The top of the Punakaiki Anticline has been eroded away leaving a band of limestone rocks which comes to the surface on the coast at Dolomite Point, *(photograph 3)*. Subsequent erosion has generated a karst landscape and weathered the rock into the distinctive "pancake" layering. Geysers of spray emerge when the tide is at the right level to force the water through the underground caverns and passages leading to blowholes.

Photograph 3: The Pancake Rocks at Panakaiki

Back to the car for the 40km drive south to Greymouth and an overnight stop. Framed in the windscreen as we drove over the bridge crossing the Grey River was a high cliff of Cobden Limestone from the Oligocene with a 25° dip sloping down to the coast. The road curved around in front of the cliff, quickly obscuring the view; it was getting too late for any more geology that day anyway. The choice of motel for the overnight stop proved to be a success. Motel rooms in NZ tend to be very well-equipped with a small kitchen area. Preparing our own breakfast enabled us to get on the road punctually in the mornings and taking a packed lunch certainly helped to maximise use of the day.

The road south from Greymouth leads to the Franz Josef and Fox Glaciers, a distance of roughly 200 km. The DOC has car parks relatively close to the glaciers and requiring a walk of perhaps 40 minutes or so. The temperature drop from the car park to the face of the glacier is sufficient to require a warmer layer and strong walking shoes are a necessity, although some people made do with sandals or even flip-flops. Schist is everywhere along the routes to the glaciers. Is it Chlorite III or Chlorite IV?; there's a lot to learn about schist.

The progress of the retreat of the glaciers has been marked with date posts by the DOC to enable visitors to imagine where they ended in earlier centuries. A lot of the rocks in the river bed at the Fox Glacier had a reddish colouring, which made me wonder what I was going to find when I got closer. In fact, there were no red rocks; it turned out to be some sort of fungal growth rather than anything geological.

The Franz Josef and Fox Glaciers occupy two long, narrow valleys fed by snow and ice from a high block of land on the west side of the Southern Alps. They end in temperate rainforest about 300m above sea level. The large catchment area feeding into narrow valleys makes the glaciers sensitive to climate changes affecting the accumulation of snow. As a result, the glaciers have enjoyed short periods of advance during the 20th century as well as major periods of retreat.

The next overnight stop was in Haast near the mouth of the Haast River. The southwest coast of the South Island is prone to wet weather and the following day started wet. There are few roads in this area and I wanted to get to the river bank near the mouth of the river to see what was there. That meant re-crossing the bridge over the Haast River: at 723m it's the longest single-lane bridge in NZ and has only two passing bays; on the other hand, there's not much traffic in the Haast area. When we afterwards drove east inland towards Queenstown, we passed unknowingly over the Alpine Fault; if there were the luxury of a marker sign by the roadside, we missed it.

More Haast Schist was in evidence along the route to Queenstown. The NZ Institute of Geological and Nuclear Science publishes detailed memoirs on selected areas with a 1:250,000 map. The relevant memoir for the Wakatipu area (QMAP 18) explains how the rocks within the Haast Schist can be mapped by a system of "textural zones". That concept was new to me and it would have been useful to have read and understood it before passing through the area.

Queenstown is the main town used as a staging post for those wanting access to Fiordland. The nearby Arrowtown is a well-preserved gold-mining town which boomed in the 1860s following the discovery of gold in the local river. There's a fair amount of geological interest in the Queenstown area but one needs to buy the local geological guide first in order to find it.

The Fiordland National Park in the south-west of the South Island is a huge, heavily-forested wilderness area that is relatively inaccessible; it was awarded UNESCO World Heritage status in 1990. The most popular access point to the coast is Milford Sound, where daily boat trips show off the features of the 16-km long fiord. Although there is a lot of geological interest en route, it's a 240-km round-trip drive to Milford Sound, which has no accommodation, and back to Te Anau, and even further to and from Queenstown. Milford Sound also has an annual rainfall of around 8 metres, yes, metres.

We chose the main alternative, a boat trip around Doubtful Sound, which is reached by another boat trip across Lake Manapouri and a coach trip over the Wilmot Pass, which links the two. The whole trip takes a day and forms a package run by a company called "Real Journeys". The quaint B&B we booked was within walking distance of the Lake Manapouri landing stage and ensured that we had a car-free day. It rains in Fiordland about 200 days a year and we were fortunate to have chosen a day that turned out to be dry and virtually cloudless.

We needed to start the journey to Christchurch. It was just over 400 km from Lake Manapouri to the Aoraki / Mount Cook Alpine Village at 760m for an overnight stop. We were now on the east side of the Southern Alps almost opposite the Fox Glacier, which is about 30 km away on the west side. (The road route between the two points is 465 km.)

Mount Cook, the highest peak in NZ at 3,754m is made of Torlesse greywacke and is obscured by cloud for most of the time. It continues to be pushed up and eroded as the rocks are scraped off the western margin of the Pacific Plate as it subducts under the Australian Plate. Part of the peak of this NZ icon fractured in 1991 resulting in a major rock avalanche and a lowering of the summit by 20m.

The final leg of our journey was to the city of Christchurch on the east coast of the South Island. The field trip to counterbalance the city centre sightseeing was to the nearby Banks Peninsular, an eroded volcanic protuberance extending about 40 km beyond the main contour of the coast into the Pacific Ocean. We were back again into volcanic territory.

The Lyttelton volcano first erupted in the Cretaceous followed by later eruptions during the Miocene when the Akaroa volcano also erupted, burying part of the south-east flank of the Lyttelton volcano; the last eruptions of the Akaroa volcano are thought to have occurred about 7.8 to 5.8 Ma. The two volcanoes originally formed an island, which became connected to the mainland towards the end of the Pleistocene as a result of sediments outwashed from the Southern Alps.

The sides of the volcanoes have been eroded by streams cutting deep channels that enabled the craters to be flooded, following the rise in sea level after the last ice age, to form the Lyttelton and Akaroa harbours.

The direct route from Christchurch to Lyttelton Harbour is via a road tunnel bored through the wall of the Lyttelton volcano and running almost parallel to a rail tunnel constructed in the 1860s with advice from the famous geologist, Julius von Haast (1822-1887).

The main road giving access the Banks Peninsular leads to the town of Akaroa on the east of Akaroa Harbour. It passes near the Onawe Peninsula, which divides the head of Akaroa Harbour into two bays. A narrow, unmade road leads around the bays to the base of the Onawe Peninsula, which is protected as it contains a Maori *pa* (fortress) site. Having found a really fascinating site, time was limited as we also wanted to explore Akaroa.

The isthmus of the peninsula is surrounded by a swarm of radial trachyte dykes, affecting the 9.1 to 8.0 Ma Akaroa cone from the earliest Akaroa eruptions. The dykes cut almost vertically through some areas of red basaltic scoria as well as horizontally across the beach to the water surrounding the peninsular. *Photograph 4* (it looks really good in colour!) shows part of a weathered trachyte dyke on the left and red basaltic scoria on the right. The scoria near the contact zone show a deep blue colouration due to baking by the trachyte. A number of the dykes are a pale cream colour and have been chemically leached by the passage of ground- and sea-water through the rocks. Some also exhibit concentric banding of orange-brown iron hydroxides. The southern tip of the Onawe peninsula has

Photograph 4: Boundary between weathered trachyte and basaltic scoria, Onawe Peninsula near Akaroa in the Banks Peninsula.

survived erosion because of an outcrop of syenite and gabbro.

After almost four weeks and 4,000 km or so we returned to the UK with a few kilos of rock specimens, having just 'scratched' the geological surface of both islands. It's amazing how much a few small pieces of rock weigh when you're close to the baggage limit.

The internet lends itself pretty readily to researching places to visit in NZ and doing advance booking of accommodation and other things. The time difference between the UK and NZ is an advantage as an e-mail sent in the evening often receives a reply by the next morning.

Like any field trip, I had successes and failures in accessing places and also in being able to interpret what I found when I got there. Despite doing a lot of preparation, it would have been nice to have obtained more knowledge of local geology before leaving Bath. I sometimes missed interesting outcrops near our route because of lack of local geological information; picking up such information as I went along was often just a matter of luck.

NZ provides a good excuse for studying areas such as volcanism, metamorphism and plate tectonics. In common with most people who have visited NZ, when we came back we felt as though we wanted to go there again for another holiday. And there is so much of geological interest too...

MORE EXTRACTS FROM TAG

Student Wisdom - perhaps it's better standing on your head!

(Herein begins a look at our beginnings as students of Geology - read and cringe)

[The quotes below are bona fide knowledge, some of it new to science, provided in undergraduate (mainly 1st year) theory and practical exams at several of our leading universities between 1990 and 2001.]

"It all began with the deposition of orthoclase".

"By the law, older things lie on top of younger ones".

"Rock type 7 was laid down under the sea, and then rock type 6 was laid down and cooled rather quickly, hence the finer grains, but I have said already that this is a metamorphic rock, so this is a peculiarity really".

The rock is a limestone because of its specific look.

This is a feldspathetic sandstone.

Rock A suggests the presence of marine life in the rock (now dead).

The sulfide particles are mainly garnet.

Because a screwdriver can't dint it, it is clearly quartz.

The outcrop consists of dacite, andesite, and rimolite.

Smith (1986) was of the opinion that the ultramafic rocks were probably not ocean crust fragments, but were ruminants of high pressure origin.

En echelon was also present.

Extensive emplacement of folitic basalts followed.

Meteorites and other attacking objects caused craters to form.

The moon was derived from one of four theories.

from TAG, September 2004