Geoscience Society of New Zealand

NEWSLETTER

Front graphic
View from Arapuni looking across at the Eastern flank of the 1.8 Ma andesitic Maungatautari volcano. 1.0 Ma Rocky Hill ignimbrite forming the prominent cliffs (Image: David Lowe)

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GEOSCIENCE SOCIETY OF NEW ZEALAND

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BRANCHES (with contacts)

Auckland:	Jennifer Eccles	j.eccles@auckland.ac.nz
GeoClub	Bruce Hayward	b.hayward@geomarine.org.nz
Geocene	Jill Kenny (ed)	jill.kenny@xtra.co.nz
Waikato:	Beth Fox	bfox@waikato.ac.nz
Taupo:	Paul White	p.white@gns.cri.nz
Taranaki:	Robert Park	park.rk.sm@sherwood-holdings.com
	Susan Burgess	susan@netmail.co.nz
Manawatu:	Julie Palmer	j.a.palmer@massey.ac.nz
Wellington:	Andrew Rees	andrew.rees@vuw.ac.nz
Canterbury:	Alex Nichols	alex.nichols@canterbury.ac.nz
Otago:	Nick Mortimer	n.mortimer@gns.cri.nz
Talks	Sophie Briggs	sophie.briggs@otago.ac.nz

SUBCOMMITTEES (with convenors)

Awards:	James Scott	jamesscott@otago.ac.nz
Fossil Record File:	Hamish Campbell	h.campbell@gns.cri.nz
Publications:	Matt Sagar	mwsagar@gmail.com
Geoheritage:	Bruce Hayward	b.hayward@geomarine.org.nz
Geophysical Affairs:	Ian Hamling	i.hamling@gns.cri.nz
Geothermal issues:		[vacant]

SPECIAL INTEREST GROUPS (with convenors)

Friends of the Pleistocene	Peter Almond	peter.almond@lincoln.ac.nz
Geoscience Education	Glenn Vallender	ge.vallender@xtra.co.nz
Historical Studies	Simon Nathan	s.nathan@xtra.co.nz
Oil and Gas	[Vacant]	
Paleontology	Hamish Campbell	h.campbell@gns.cri.nz
Sedimentology	Mark Lawrence	M.Lawrence@gns.cri.nz
Geochemistry	James Scott	james.scott@otago.ac.nz
LAVA NZ	Adrian Pittari	apittari@waikato.ac.nz

ARCHIVIST:	Catherine Reid	catherine.reid@canterbury.ac.nz
WEBSITE:	Hugh Grenfell	h.grenfell@orcon.net.nz
SOCIAL MEDIA		[Vacant]

Geoscience Society of New Zealand

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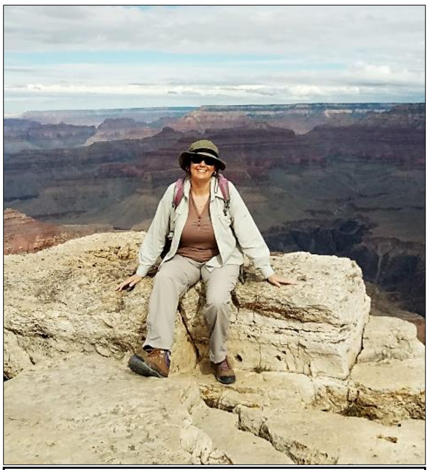
FROM THE PRESIDENT



Jennifer Eccles

It seems only a moment ago I was agreeing to be nominated as President with the caveat that I would actually be on Research and Study Leave (aka sabbatical) in 2019 yet now I write my last President's page from the USA. My tenure has been one seeing much structural transition with Alan Orpin doing a fantastic job streamlining financial systems as Treasurer and Nicki Sayers settling in well to the administrator's role and using her rich experience to encourage us to begin to formally think more strategically as a committee about the Societies activities and future. A website development is underway that we hope to reveal to you all soon, and I'll take this opportunity to sincerely thank Hugh Grenfell for his long-term efforts as the GSNZ webmaster maintaining the current (and previous) website. We mourn the recent loss of former long-serving Treasurer David Skinner in August, just a year after his final accounts were audited. His contribution to the society was acknowledged with an Honorary Member Award in 2014 and it was my delight and privilege to have had the opportunity to have known him through the GSNZ. The current conference organising committees also feel the reality of the 'post-Janet's retirement' world after her swansong at the very successful Napier Geosciences 2018 conference with transition to a less affiliated and GSNZ-experienced conference organisation services. I was delighted to meet many of you on my President's Tour.

After six years on faculty at the University of Auckland I have had an opportunity to take my first Research and Study leave. Released from the formalised schedule of semesterised teaching and an imminent case of burnout, particularly after a high intensity summer leading an effort to submit an ~250-page long Endeavour Fund proposal to MBIE, I now better appreciate the value of this opportunity. I have enjoyed the increased flexibility to travel, have time uninterruptedly devoted to research and step back to think big and strategically again and to get recharged and re-inspired about geoscience. After being in the SW USA for a geophysics conference that left me again astounded at the speed, technologies and sophistication that industry research can facilitate I took the opportunity to visit the US geophysical instrument pool and knock an item off my bucket list by taking a week long holiday road-tripping through New Mexico and Arizona, visiting the Rio Grande Rift and Grand Canyon. Beyond my own interest the superb job these sites are doing for educating the public makes me think what more New Zealand could do at some of our own geological wonders.

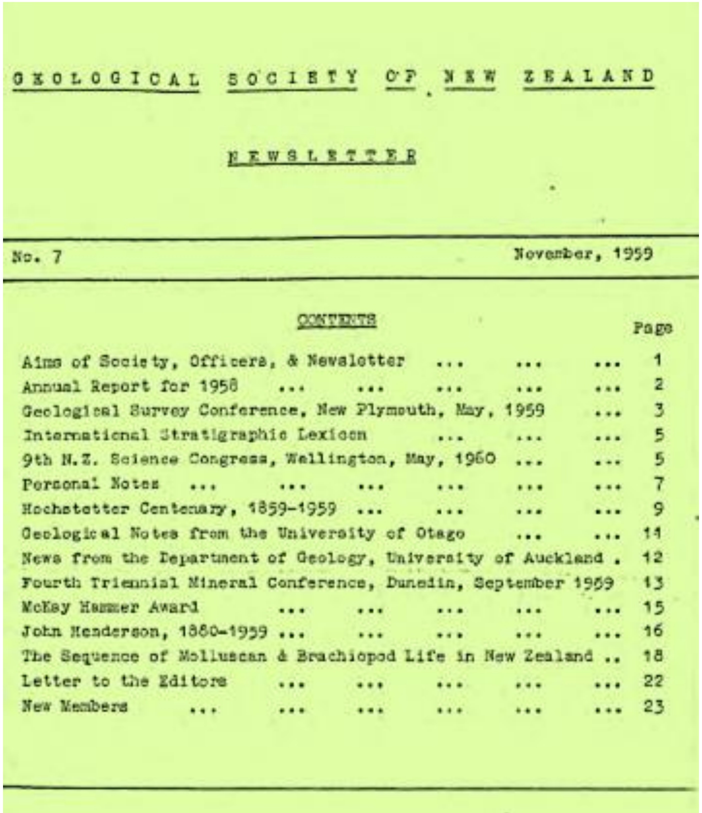
My apologies in advance for not being physically present with you at the Hamilton Geosciences conference and AGM at which I will officially be succeeded although I will have been active behind the scenes to the end. At the time of press of this newsletter there is potentially still opportunity to get more involved with the national committee for 2019-20; particularly if you would like to see any change the best place to make this happen is from within. I've also been conscious that the gender balance has shifted over the last few elections as resigning female representatives of branches have been succeeded by males without necessarily the reverse occurring so I would particularly encourage any women, but particularly those who would eventually aspire to an executive or leadership role, to let us know of any interest. I wish you all the best for a successful conference.

EDITORIAL

Glenn Vallender

So, another 'editorial' year comes to an end.
One of the 'advantages' of having a full set of Newsletters filling up cupboard space is being able to pick out an old Newsletter at random and enjoy reading the real thing. But of course, having the digital copies available online is even better because one can 'cherry pick', copy, cut and paste materials that once were of cutting edge knowledge or even controversial. Science works by critically examining evidence and discarding concepts that do not adequately explain. Isn't it amazing that instead of discarding, the original concepts often still hang around and continue to influence thinking. So what did happen to the New Zealand geosyncline concept, and will the holistic 'terrane grafting' concept still be with us in 50 years time?

The picture opposite shows the contents page for the older Geological Society's Newsletter issue #7 of 1959. Contrast this with the contents pages for issues 27-29 of 2019. There was not a single image in the #6 issue and all type written and lovingly stapled together and no doubt stamps being licked. The total membership reported in this issue was 260 (several who were unfinancial!), 50 of whom were international. Roger Cooper, Peter Barret, Malcolm Laird and Alex Mallahoff were new members that year. I guess the only way to learn from history is to know what that history is. There were three Newsletter editors for issue #7, but you can find out their names by downloading the issue for yourelf http://www.gsnz.org.nz/information/newsletter-archive-i-58.html. Interestingly, in Issue #6 (May, 1959), there was a motion by Charles Fleming "That the Newsletter should not publish scientific and technical names that are nomina nuda" [naked names, whatever that means] was carried, but an attempted amendment by David Kear to add Formation names was defeated! Gosh!



GEOLOGICAL SOCIETY OF NEW ZEALAND

NEWSLETTER

No. 7 November, 1959

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A very big thank you to all contributors for 2019, enjoy issue #29 of the Geoscience Society, have a great conference and a happy festive time with friends and family. Keep safe and I look forward to your contribution for 2020.

ARTICLES

GNS Science shifts gear with an eye to the future

John Callan GNS communications advisor J.callan@gns.cri.nz

GNS Science has recently refocused its science priorities and adjusted its structure to capitalise on its core strengths and respond more effectively to the present and emerging needs of New Zealand. The changes are more incremental than seismic and are the result of an internal review as well as extensive consultation with stakeholders.

Some things about the organisation haven't changed. It still produces outstanding science, is still a very willing collaborator, and still operates its world-class facilities such as the Water Dating Lab, the Rafter Radiocarbon Dating Lab, the Ice Core Research Facility, and its 24/7 National Geohazards Monitoring Centre.

The top-to-toe review highlighted the importance of being more outwardly focused, being a valued thought leader, and having a structure that allows rapid adjustment to the changing needs of end-users. In spite of being well known for delivering excellent, internationally-recognised science, it became clear that more could be done within the organisation to ensure that high-impact science was reaching the right end-users. In addition, GNS could see the need to quantify the impact of that work. To achieve that, it needed to have the right structures, culture, and capability in place. Science is changing, not just in New Zealand but globally too. Increasingly, science is being asked to deliver 'whole solutions' to complex issues. There is greater need for effective interdisciplinary research, and independent science commentary that meets the needs of policy-makers and decision-makers. This brings a sharper focus to science engagement and knowledge-brokering to diverse communities, including Māori.

There is also a growing expectation that science organisations can demonstrate and measure the impact of their work. For GNS this means it needs a clear line of sight from its science to the benefit it delivers for New Zealand. A crucial part of this is strengthening end-user relationships. A first step for the organisation was to boost its corporate functions to improve support for its science programmes. This has included beefed up stakeholder relations and communications teams, as well as project management specialists embedded in the science groups. Vision Mātauranga has been woven more explicitly into the refreshed science programmes to underline a commitment to developing partnerships with iwi/Māori interests. With the corporate functions improved, the next stage was to refocus the organisation's science divisions by setting up four high-level science themes. Each theme has four or five research priority areas. Some staff are focussed entirely on the one Theme, while others work across two or more. Under the new structure, science teams are typically smaller, more nimble, and more collaborative both internally and externally than in the past.

Changes in emphasis in science direction are already evident in several areas across the organisation. For instance, GNS Science was recently successful in being awarded funding under the Government's Endeavour Fund for two new research projects. The first will see GNS lead a five-year international programme to better understand deep geothermal resources under the central North Island. Super-hot fluids at depths between 3km and 6km have the potential to deliver 10 times more energy than conventional geothermal energy for the same amount of fluid extracted. The goal of the new programme is to increase the contribution that geothermal makes to New Zealand's energy mix to help meet the net zero emissions target by 2050. Currently geothermal contributes 17.5%. Exploration over the next 20 years will inevitably move toward deeper and hotter geothermal resources. The programme is designed to increase the understanding of deep geothermal resources so GNS can offer new information and understanding to the energy industry looking to explore this new frontier.

The other recently funded Endeavour research programme will leverage GNS's expertise in nanotechnology to develop novel catalysts to help in the production of hydrogen and the efficient operation of fuel cells. This will help to make hydrogen a more attractive proposition as a fuel and an energy carrier.

Another example is a renewed focus on the quality and quantity of groundwater, with aquifers supplying 40% of New Zealand's drinking water. The importance of this resource cannot be over-stated with climate change and increasing population density putting extra pressure our groundwater systems. GNS is a sector leader in improving the understanding of New Zealand's 200 known aquifers so they can be managed sustainably.

GNS sees engaging with iwi/Māori as an integral part of its work. In practice this means it has built, and is building, strong relationships with iwi groups and Māori interests through the country. Its engagement approach aims to ne inclusive and consider the perspectives and cultural values of iwi, hapū**,** whānau, and Māori. As part of this, GNS is embedding Vision Mātauranga (VM) right across the organisation. VM is a government framework designed to unlock the innovation potential Māori knowledge, resources and people to benefit all New Zealanders.

GNS's four high-level Science Themes are – Natural Hazards & Risks, Environment & Climate, Energy Futures, and Land and Marine Geoscience. A description of the themes is as follows:

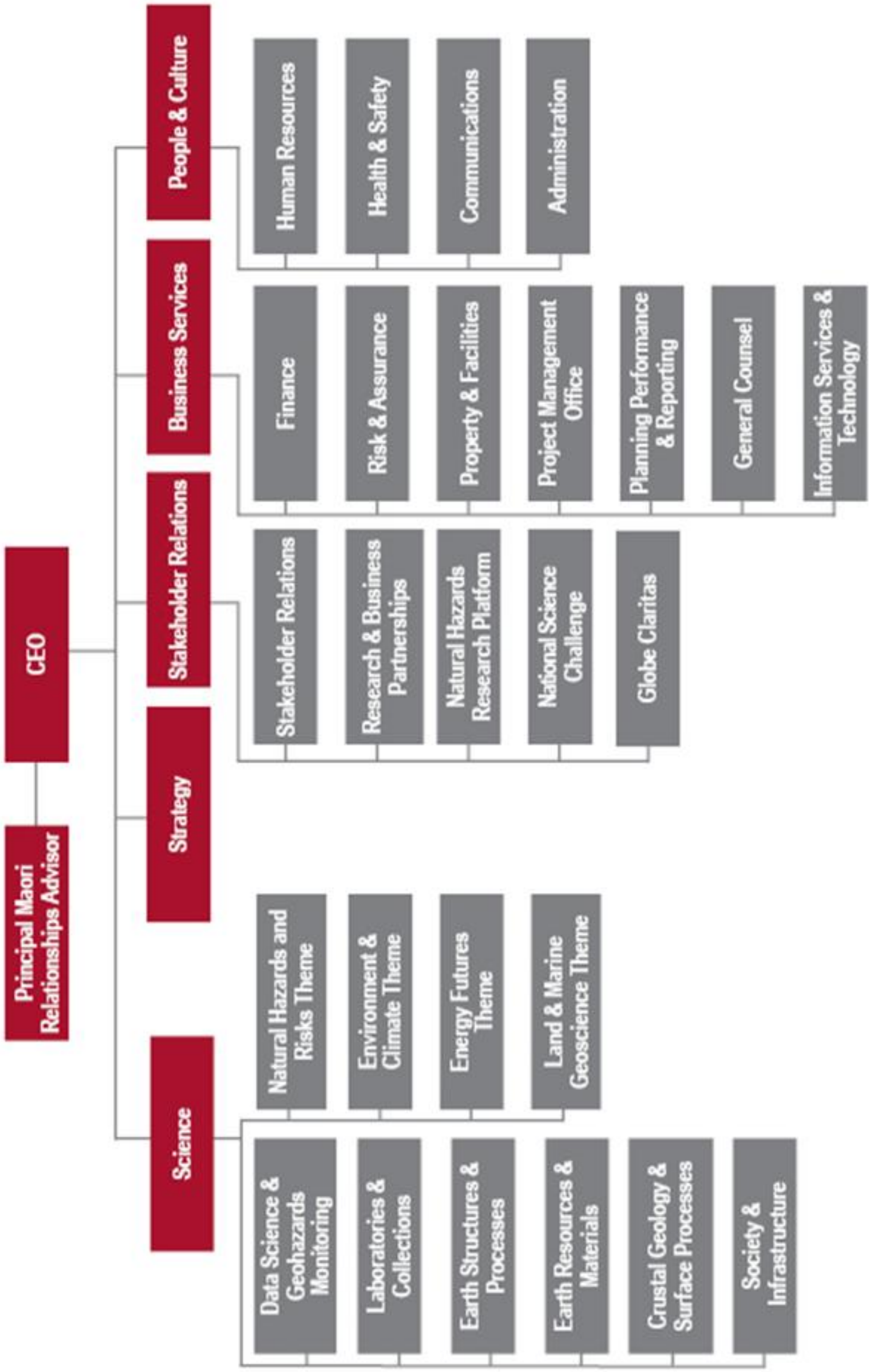
Natural Hazards & Risks Theme	
Key elements	**Workstream outcome**
Better risk mitigation planning	Information and tools that help response agencies deliver more effective and timely mitigation plans. Also enables the design of safer buildings and infrastructure.
Natural hazard risk modelling	Comprehensive modelling for refined hazard-risk assessment, risk-based land-

	use planning, informed emergency responses, and prudent investment in mitigation and risk transfer mechanisms
Improved preparedness for hazard events	Early warning/forecasting for all perils leading to more timely decision-making by Civil Defence and other response groups.
Better informed public, iwi/Māori and business	Hazard, risk, and resilience research is embedded in policy and with stakeholders so NZrs can respond effectively to natural hazards
Environment & Climate Theme	
Key elements	**Workstream outcome**
Better groundwater management	Comprehensive mapping and quantifying of NZ's main groundwater systems to improve freshwater security. Leads to better management of this crucial resource.
Enhanced ecosystem management	Document the response of our native terrestrial vegetation and ocean plankton to past warm intervals in Earth's history. This will inform NZ's ecosystem management plans.
Improved climate projections	Better handle on the likely response of our climate to increased surface temperatures. Models capture variabilities and feedbacks and guide NZ's climate adaptation response.
Adapting to environmental change	Improved clarity of Antarctic ice sheet contribution to global sea level change. This leads to improved projections for the NZ coast and better adaptation to change.
Improved understanding of our carbon emissions	Carbon budgets for NZ's four main centres leading to better reporting to meet NZ's commitments to the 2016 Paris Agreement.
Energy Futures Theme	
Key elements	**Workstream outcome**
Increased access to renewable energy	Increased contribution to NZ's total energy needs from secure and sustainable geothermal energy. This is fired by greater uptake of world-leading geoscience information and modelling to assist the geothermal sector.

Reduced CO_2 emissions	Accelerated development and uptake of next-generation renewable energy resources to usher in a low emissions future.
Optimised geothermal energy	New understanding of NZ's geothermal resources to reduce environmental impacts and improve investment and resource planning.
Next-generation energy efficiency & generation	Assist with technological innovations that increase energy efficiency or enable novel energy generation. This leads to more energy-efficient primary and manufacturing sectors, and greater wealth creation.
Land and Marine Geoscience Theme	
Key elements	**Workstream outcome**
Improved resilience to natural hazards	Better understanding of Te Riu-a-Ma-ui/Zealandia's geohazards to strengthen NZ's resilience to natural hazards.
Managing natural resources sustainably	Enhanced management of NZ's land and marine resource endowments through more accurate characterisation of the composition and structure of Te Riu-a-Ma-ui/Zealandia.
Adapting to climate change	Acquiring baseline paleo-environmental data to better understand the consequences of past ocean and climate change on Te Riu-a-Ma-ui/Zealandia. This will inform forecasts of future climate change and development of adaptation strategies.
Wider use of collections and databases	Aim for wide use of our most important databases and collections to deliver new insights and context for applied geoscience, education, industry, policy setting, and community engagement.

A more comprehensive overview of GNS Science will be available in its 2019 Annual Report, available here: https://www.gns.cri.nz/Home/About-Us/Corporate-Documents/Annual-Reports.

The refreshed structure (see graphic) reflects a stronger focus on outcomes. To meet the challenges outlined above, staff numbers have grown slightly to 440. The organisation continues to operate from five locations – Lower Hutt (Avalon and Gracefield), Wairakei, Auckland and Dunedin. The management team and the majority of staff are based in Lower Hutt, with smaller offices in the other centres.



Principal Maori Relationships Advisor
CEO
Science
Strategy
Stakeholder Relations
Business Services
People & Culture
Natural Hazards and Risks Theme
Environment & Climate Theme
Energy Futures Theme
Land & Marine Geoscience Theme
Data Science & Geohazards Monitoring
Laboratories & Collections
Earth Structures & Processes
Earth Resources & Materials
Crustal Geology & Surface Processes
Society & Infrastructure
Stakeholder Relations
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Natural Hazards Research Platform
National Science Challenge
Globe Claritas
Finance
Risk & Assurance
Property & Facilities
Project Management Office
Planning Performance & Reporting
General Counsel
Information Services & Technology
Human Resources
Health & Safety
Communications
Administration

Oil and Gas: How much longer?

Roger Brand (brand.r@xtra.co.nz)

After a week of international and local demonstrations concerning the progressively developing crisis of climate change, I would like to comment on how I see the oil and gas industry faring in New Zealand over the foreseeable future.

The effect of banning further offshore oil and gas exploration has been commented upon in previous Geoscience Newsletters (Uruski & Haw, Brand (July 2018), Wood, Uruski (March 2019)); these views coming from proponents for further oil and gas usage as with the worldwide outlooks provided by BP, Exxon Mobil and the IEA (largely USA policy). The economists at NZIER also wade in with predictions of significant New Zealand economic downturns as a result of the drastic reductions in oil and gas exploration.

In the green corner, we hear from the environmentalists (e.g. Greenpeace, 350 Aotearoa, Zero Carbon Act NZ) that the onus is on the oil and gas industry to curb its production (nigh to abandon it altogether) with the vision of reaching net zero carbon by 2050.

The NZ Government is playing the diplomatic role and treading softly through the process of consultation, most recently with the 'Productivity Commission low-emission economy' report in 2018 and the Climate Change Response (Zero Carbon) Amendment Bill report (due October 2019) which includes improvements to the ETS.

At present indigenous oil and gas production (270 PJ) provides approximately half of our hydrocarbon consumption, and reserves (2500 PJ) are expected to last another ten years. No significant new discoveries have been made since the Tui Oilfield in 2003; with Pohokura Gasfield in 2000. Even before the ban on new offshore exploration, very few wells were being drilled (two in 2016) and major oil companies (Exxon Mobil, Statoil, Anadarko, Woodside, Petrobras and Shell) had already quit NZ exploration due to perceived lack of prospectivity and the cost of development. There is also the likelihood of partial asset stranding on new projects, especially in deepwater, where there is a long lead-time between discovery and initial production.

With the price of oil at around US$60/BBL, I suspect the ban has made little difference to the level of exploration drilling. Its negative effects have been more closely felt by workers in the technical and support industries, especially in Taranaki.

None of this however dictates what is to become of the oil and gas sector though 'business as normal' is long past. Can we continue to import vehicles and burn through 8 billion litres petrol and diesel each year? Assuming taxes and levies amounting to 96c/litre, we are then paying around $10 billion each year just to fuel our domestic transport.

Given a time frame of thirty years to achieve a net zero carbon economy we could steer the $300 billion spent on petrol and diesel into a substituted energy source for our domestic transport; when and whether this is electricity with/without hydrogen is reliant also upon development of necessary changes in propulsion for cars and appropriate distribution networks.

Nonetheless, we have to consider a suitable alternative energy mix to substitute for the domestic fuel requirement, currently around 250 PJ. One possible solution is to increase both the present geothermal (27 PJ) and wind (8 PJ) output by five times, solar (1.5 PJ) by ten times and with hydrogen providing another 10 PJ, this gives 200 PJ. Also we might assume that a transition to greater public transport improves the overall efficiency by 20% such that the new requirement becomes 200 PJ.

For these developments to eventuate, a new electricity market needs to encompass both supply and demand: that is in both generation and electric vehicles. It is possible that as Ray Wood says 'planning consents and construction of this infrastructure would take decades'. A similar timing scenario beset the oil and gas industry in the 1960s when it took twenty years from the initial discovery (Kapuni-1) for the gas market to be created by Government in the 'think big projects' that enabled full production to proceed, post Maui.

For the Geoscience community, discussion is required on the possibilities for further geothermal generation in the central North Island, coupled with the long-overdue establishment of a legal framework covering licensing and taxation. What does it take to increase five fold the geothermal power output? For example, Contact Energy has at least spent $30 million on development drilling at Tauhara for another 8PJ.

Consultation is also required on how best to use our existing gas resource (c.1900 PJ). At present we are using 180 PJ per year of which 45 PJ goes into electricity generation. A similar amount is sold to Methanex and converted into methanol purely for export. Without the chance of further gas discoveries it is likely that our gas resource would be seen more as a strategic asset, useful in the times of low hydro-flows. As such, the resource may last beyond the foreseen ten years.

So, the banning of further offshore exploration is just the beginning of much larger ideological and fiscal changes that the Government needs to make in order to achieve a small modicum of adherence to what we signed in 2016 following the UN Paris Climate Change Accord. My belief is that the change away from oil and gas in NZ has been made and the sooner we support the Government in funding new energy projects and infrastructure, the sooner our economy and health will be on a more sustainable footing. If it's going to take ten years, then Time is of the Essence.

The 2019/20 Drilling Season

Chris Uruski

Despite the government ending petroleum licence rounds, current exploration and production permits continue to operate normally. The state-of-the-art semi-submersible drilling rig, COSL Prospector has been working for Tamarind Resources on the Tui oil field since June and will continue to do so probably until October. OMV will then use this rig to drill one exploration well in the Great South Basin and three in Taranaki. In March next year, the Archer Emerald is again to be mounted on the Maui A production platform to drill up to five wells targeting by-passed gas that will be produced to extend the life of the field that has supplied much of New Zealand's gas since 1979.

Meanwhile, Greenpeace and its minions have been vociferous in expressing their "outrage" that such a thing could be allowed to happen and they've run courses on how to protest against this activity. If events unfold as in the past, we can expect protest vessels making nuisances of themselves and helicopters filming operations in the hope of something to report. When they return to port, it will be to "replenish", not to refuel with diesel, petrol and jet fuel. This allows the protestors to believe that they occupy the moral high-ground, although in reality, they are admitting that there is no viable alternative to using the substance they believe must be left in the ground.

It seems that most people today believe that New Zealand, along with the rest of the world, needs to reduce carbon emissions. There is a strong feeling that if we stop producing petroleum, we won't have it to burn and something will come along to replace it. Sadly, that is unlikely to be the case, it's always ***them*** who are responsible for the problem, not ***us*** and ***they*** who we hope will come up with a solution. But petroleum, like any other commodity, is demand driven and we demand to be supplied because, otherwise life would become unbearable. The devil is always in the detail. Several factors are involved with the uptake in electric vehicles. Last year more than 200 Ford Ranger twin-cab utes alone were sold in New Zealand for every electric car. Why? Because they are currently more attractive and practical; because there are not enough re-charging stations, because there are not enough electric cars. Whatever happens to import taxes, it will still take decades before the majority of the vehicle fleet is electric. At the same time, generating capacity must be increased to power these vehicles. At present, petroleum powered cars use as much energy as is generated in the country, suggesting that generating capacity needs to be doubled over the next couple of decades. There may be a way to do so, but it will certainly require natural gas to take up the shortfall in generation from renewable sources.

So far, New Zealand petroleum production has been dominated by natural gas and gas is more likely to be found by new exploration drilling than oil. If drilling in Taranaki yield an increase in gas production, it can be fairly readily utilized as there is already a fair bit of infrastructure in the region, including agrichemical plants that use gas to make urea. If a very large gas field were to be discovered by OMV in the Great South Basin, the size of the field might justify its export as LNG, which could replace coal for electricity generation in several countries and reduce CO_2 emissions. If it is only as big as Maui for instance, it may well end up making South Island self-sufficient in energy for a couple of decades or so. Gas heaters could replace lignite in Southland fireplaces and wood burners in Christchurch giving reductions in CO_2 emissions and clear skies in Christchurch. It is easier and cheaper to make hydrogen from natural gas than to electrolyse water, so plentiful gas could make a hydrogen economy viable.

……………………………………………….

Overseas observations relevant to the establishment of global Geoparks in New Zealand

Bruce W. Hayward

In 2018 the New Zealand National Committee for UNESCO called for Global Geopark proposals for New Zealand and selected a Waitaki Whitestone proposal to be developed to a full application to be considered by UNESCO Global Geoparks in Paris. "UNESCO Global Geoparks are single, unified geographical areas where sites and landscapes of international geological significance are managed with a holistic concept of protection, education and sustainable development … [they] promote sustainable local economic development mainly through geotourism. In order to stimulate the geotourism in the area, it is crucial that a Geopark has visibility with information provided through a dedicated website, leaflets, and detailed map of the area that connects the area's geological and other sites … It is a pre-requisite that all Global Geoparks develop and operate educational activities for all ages to spread awareness of its geological heritage and its links to other aspects of their natural, cultural and intangible heritages:

Geoparks are expected to actively involve local and indigeneous peoples, preserving and celebrating their culture … The defining geological sites must be protected by indigenous, local, regional and/or national law".

In the 15 years since the concept was introduced there have been 147 Global Geoparks accepted in 41 countries, mostly in China (39) and eastern Europe (26), where more traditional conservation methods such as National Parks and conservation reserves were not well advanced.

With the possibility of several geoparks being proposed in New Zealand in the near future, my wife and I took the opportunities while on recent overseas' travel to seek out and visit five existing geoparks in three countries: Reykjanes (Iceland), Katla (Iceland), Fforest Fawr (Wales), Geomon (Wales) and Langkawi (Malaysia). There is a vast difference between researching and reading about a geopark on the web or being shown around by an official guide from actually visiting as a tourist and observing the response of actual visitors.

The first thing that became clear was that each Geopark appeared to have been set up with public monies to establish the infrastructure. Each consisted of a number of separate geosites which had visitor parking and panels explaining the mostly geological “attraction” but sometimes the geosite might be partly or totally biotic, cultural or historic in nature, loosely connected to the geology, landforms or soils.

Langkawi Global Geopark was set up in 2007 partially to attract tourism back to the island after the setback of the 2004 tsunami damage. It seems to have been the best-funded and to be the most successful of the five visited. Langkawi is a major tourist destination (3.7 million p.a.) for its duty-free shopping and beach resorts. The Geopark is themed around “the best-exposed and most complete Paleozoic sedimentary sequence in Malaysia.” The names of its three parts – Machinchang Cambrian Geoforest Park, Kilim Karst Geoforest Park and Dayang Bunting Marble Geoforest Park are liberally splashed across noticeboards and other places (Fig. 1) and the locals are very proud of them. There are many well-developed tourist sites often labelled as one of the 90 chosen geosites with noticeboards explaining features of the local geology (Fig. 2). My observations were that most of these geoexplanations were ignored by the tourists as uninteresting and the attractions were the views, the beaches, the adventure activities and the natural fauna and flora. One classic example of the failure of a geosite to attract visitors was the summit of the highest, tropical-forest covered mountain Gunung Raya (881 m) in Langkawi. It has a multimillion dollar road and water pipeline lleading up 15 km to the top. A tea house, tourist hotel (2 restaurants) and 5-storey viewing tower with elevator had been constructed on the top (and are still advertised) but all were closed-up and derelict and clearly had been a financial disaster. The geosite attraction was proclaimed on signposts as being the treasured roof pendant of Paleozoic sedimentary rock that capped the top of this Triassic granite mountain. The sign showed a photo of a grass-covered road cutting but today even that was impossible to identify. A roof pendant and views through the clouds had not been enough to sustain the tourist infrastructure.

Fig. 1. The name of part of Langkawi Geopark attached to cliffs below limestone pinnacles.

Fig. 2. Part of a geoexplanation noticeboard that explains the formation of granite by comparing it to ice-creams! Langkawi Global Geopark.

Probably the most visited and popular geosite is Machinchang Peak, Langkawi's second highest massif, made of eroding Cambrian sedimentary rocks. The two lookouts at the top have noticeboards explaining the peak's two most outstanding geological features – tafoni weathering and ripples on a bedding plane. I seemed to be the only one of dozens of people up there at the time who paid any attention to the notices. Unfortunately, I never found any tafoni and came across the rippled bedding plane by accident, well away from the noticeboards and partly obscured by vegetation. Clearly it is not these underwhelming geologic features that are the attraction for the estimated 5000 visitors each day. It is the 2 km-long and steepest cable car ride in the world that has to be taken to get to the top and the 125 m-long Sky Bridge you can also pay for to walk between two peaks. Sky Cab was opened in 2003 and Sky Bridge in 2005, both before the Geopark was established. So in this instance the geopark has piggybacked on an existing major tourist site. Many of the Malaysian visitors have heard that this massif is the birthplace of Malaysia but most (including our nature tour guide) had a concept that the massif was formed during the Cambrian and progressively the rest of Malaysia was added on to it. Although there are signs explaining how the sediments were the oldest to be deposited on the seafloor in the region and were progressively buried by further sediments during the Paleozoic before being uplifted and eroded.

Many locally-run tourist ventures do owe their existence to the Langkawi Geopark. Most are water-based adventures on local long-tail boats through the mangrove waterways or to island hop between islands. The background scenery consists of spectacular limestone and marble pinnacles and cliffs of high geoheritage value but most tourists are focused on feeding the monkeys or sea eagles, swimming in the large freshwater lake on Pulau Dayang Bunting, or viewing the 1500 bats hanging from the ceiling of a limestone cave. Our local nature guide said nothing about the fantastic biokarst at the entrance to the bat cave nor had any clue why there was a freshwater lake in the middle of an island (drowned huge doline in marble). He did however take a dim view of those operators who were feeding the wildlife.

There were a number of small geopark information centres. The best, in the commercial village at the foot of the Sky Cab, had superb geological displays but we were the only visitors. A new, much larger Discovery Centre is about to open at Kilim River jetty with a major focus on community and school education on all aspects of the natural, historical and cultural heritage of the geopark and I am sure will attract a much larger audience. I understand that there are already quite a few geopark programmes in Langkawi schools and this education of the younger generation may be one of the greatest strengths of the park.

In contrast to Langkawi, Reykjanes and Fforst Fawr geoparks were both established to try and attract people to little visited areas. **Reykjanes Geopark** is centred on a small peninsula 30 mins drive west of Iceland's main city, Reykjavik, and close to the airport which receives 3 million tourists each short summer. All tourists do the 1-2 day Golden Circle route from Reykjavik through the Thingvellir National Park rift valley and Geysir geothermal area and perhaps 20-30% take the 1-2 week Full Circle right around the island. Reykjanes Geopark is a backwater away from both of these routes but large numbers of visitors make the pilgrimage to one attraction on the peninsula – the hugely expensive Blue Lagoon geothermal pool (Fig. 3). They come in bus loads to the pool, stay a couple of hours and never venture any further.

The Reykjanes Global Geopark was established in 2015 and is centred around the mid-Atlantic Ridge exposed above sea level and the evidence of volcanic activity that has shaped the peninsula. We made a special trip to visit a few of the 55 geosites and concluded that the geopark is having minimal effect with fewer than 1% of Iceland tourists venturing out that way. There was no obvious commercial tours, attractions or bus trips and we never found the small visitor centre (in Duus cultural house). Directions to the various 55 geosites were poorly signposted but when we found them there were excellent explanatory geological boards. The most popular site was a newly built pedestrian bridge over a dry, 20 m-wide, 5-m deep rift in the basalt (Fig. 4) that was claimed to be the mid-Atlantic Rift. It is known as the “Bridge between Continents” (= tectonic plates). Quite a bit of public money had been expended in establishing the Geopark but my assessment was that it had almost no economic benefit to the very few local residents or businesses. At most it provided something different for tourists to do with half a day to spare while waiting for their flights out. The biggest achievement of this Geopark was that it had raised awareness among locals of the geoheritage of their area with consequent geoheritage conservation benefits.

Fig. 3. Blue Lagoon geothermal pool (entrance ticket NZ$75-120) is the main attraction on Reykjanes Peninsula (nearly 1 million visitors p.a.) but it is not part of the surrounding Geopark which I estimate attracts ~1% of that number.

Fig. 4. This “Bridge between Continents” was constructed in Reykjanes Geopark over this narrow rift claimed to be the on-land extension of the mid-Atlantic ridge.

Fforest Fawr Geopark (established as a Geopark in 2005 with Global Geopark recognition in 2015) was quite different as it has been established in the western half of the existing Brecon Beacons National Park (south Wales) with the geosites already well-protected. I was told that the aim of the Geopark was to attract tourists to this less-used part of the National Park and spread them away from the congested hiking trails in the east. The only geotourist operator in the area said he feels the geopark establishment has had little impact on visitor numbers, the eastern part is still congested and the small number of visitors expressing an interest in the geology hasn’t increased. Most of his work is guiding hikers over the trails and not specifically on one of the nine geotrails established within the Geopark. Establishment of the Geopark attracted significant public funding for the first few years with several staff employed to prepare information panels, leaflets and a Geopark information area in part of the national park visitor centre. Funding has since declined and the visitor centre has become a souvenir shop and café. We had to ask where there was information on the Geopark – hidden away on shelves in one corner. I have read on-line that a new Geopark hub is about to be opened in the Swansea Valley and hopefully this will make up for the information centres that were closed in 2016.

Using the narrow roads of rural Wales, the Geosites were hard to find and poorly signposted and the most visited sites were those that were historical, like castle ruins on a limestone hill (Fig. 5). Most visitors were not aware these sites were in a Geopark or that the Geopark even existed. Yes the Geopark has resulted in greater availability of information on the geoheritage of the area but only a small percentage of visitors appreciated this.

Fig. 5. Carreg Cennon Castle located ona small limestone hill is one of the most visited geosites in Fforest Geopark, south Wales.

Geomon Geopark in north Wales encompasses the isle of Anglesey (Mon) and celebrates its geodiversity spread through 12 geological periods and 100 rock types. This geopark seems to have similar identity problems to all the parks we visited (except Langkawi) and signposting to actual geosites is poor or non-existent. The sites are few (6 geosites, 6 geotrails) and widely spread around the island which makes it a challenge to find and view more than 3 or 4 in a day. The most visited site is the cliffs of South Stack, with most visitors coming to see the nesting seabirds and trying to catch a glimpse of the elusive few puffins. When we visited I seemed to be the only one taking pictures of the spectacularly-folded Cambrian schist. We made two visits before we stumbled across another geosite which highlighted a foreshore exposure of mélange with hand specimens of each of the different rock types glued onto plinths with short explanatory text (Fig. 6). Having discovered on-line that there was a Geopark visitor centre in an historic maritime building in Porth Amlwch we made a detour to visit it and perhaps get some tips on which of the geosites they recommended as the most exciting to visit. We strolled along the pier and thought we had found the information centre but it turned out to be the Copper Kingdom Centre, a commercial tourist centre celebrating the historic copper-mining area (not part of the Geopark). They kindly pointed out the little building that contained the Geopark centre. The small cramped room was full of geology books, maps and a few specimens and was manned by an enthusiastic volunteer, who could not answer my most basic questions such as how to get to certain geosites and what was there to see. Rather like Reykjanes, I think Geomon Geopark has increased local appreciation, education and conservation of the geoheritage but has had minimal impact in attracting new tourists or local tourist ventures.

Fig. 6. One of several plinths with identified rock samples (Cambrian schist, serpentinite and quartzite) like those in the adjacent mélange at Cemaes Bay Geosite, Geomon Geopark, north Wales.

Katla Geopark is on Iceland's Round the Island circuit and as such already has hundreds of thousands of visitors passing through each year. Once again the existence of the Geopark is low key and we never found an information centre although we visited a brand new commercial, high-tech Lava Centre in the vicinity. Many of the major scenic attractions alongside the popular circuit road are classified as geosites and include several amazing waterfalls crashing down over the uplifted Holocene basalt sea cliffs, two perfect columnar-jointed basalt sites (Fig. 7), and a wave-swept rocky point of basalt and peperite at Dyrholaey, all of which would have been popular stops before the Geopark was created. Many new geosites seem to have been identified or created as additional attractions, such as a field of pseudovolcanoes (formed when lava flowed into a wetland at Landbrotscholar) and a walk around the crest of Fjadrargljufur canyon through badlands topography. What has this geopark achieved? I doubt that its existence has attracted any additional tourists to this already popular area. Maybe the additional sites have encouraged some to spend a few hours longer in the area or even an extra night, and the existence of the Geopark will have enhanced geoheritage conservation and appreciation of it by the 3000 locals who live in the area. Explanatory geological and faunal signboards are present at all the geosites but we noted they are also present at many other sites around the Iceland circuit that are not in a geopark.

Fig. 7. Dverghamrar is a geosite featuring unusual columnar jointed basalt in Katla Geopark, Iceland.

Conclusions

So, from my biased random observations of just five geoparks what can we expect from the creation of one or more Geoparks in New Zealand? Clearly, they will need considerable input of public money to get them up and operational and this will come with an expectation of increased visitors staying in the area with consequent increased economic return. This is certainly the scenario for the Waitaki Whitestone Geopark proposal where Waitaki District Council has already invested considerable resources in the application process. I cannot see the four most popular existing tourist attractions in the Waitaki District – Moeraki Boulders, Oamaru blue penguin colony, Oamaru's historic limestone buildings and Clay Cliffs, Omarama – being usurped. Clearly it will give the Vanished World trail and visitor centre greater exposure, but the challenge will be to make tours of the Vanished World sites with charismatic geoscience-savvy guides a full-day "must do" attraction. For impact and delivery, each geopark needs to establish one or more information/interpretative centres at locations that already attract the most visitors – like Moeraki Boulders and Oamaru's limestone heritage buildings precinct. Sorry Vanished World but a fossil museum away from Highway 1 in Duntroon will find it hard to attract large numbers of visitors unless the word dinosaur is in the title.

If the Global Geopark is accepted we can expect a consequent increase in local appreciation of their geoheritage and acceptance of some level of legal protection (e.g. ONF, QE2 covenants) for nominated geosites. Maybe some new locally-run nature and geotourist ventures will spring-up but to be successful they will need that wow factor and some knowledgeable and enthusiastic operators. I cannot envisage the internationally-spectacular Oamaru pillow lavas ever rivalling the nearby penguin colony in tourist appeal? Maybe a geohistorical attraction could be created at Parkside Oamaru Limestone Quarry that links the origins and characteristics of New Zealand's most important building stone with the history of its extraction, shaping and use.

The establishment of Global Geoparks in New Zealand could open many opportunities for geoeducation, geotourism and geoconservation, but my observations overseas suggest that getting local public buy-in and support will be challenging. Continued, long-term public funding will be essential and this will require demonstrated substantial economic benefit to the area, probably in terms of increased visitors and bed nights. Are NZ geoscientists ready to step up to the plate and take advantage of the opportunities?

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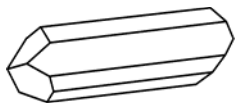
GEOSCIENCE QUIZ 29
by Aenigmatite



1. What is trinitite?
2. For what is the acronym KREEP used?
3. Prior to their amalgamation in 2010-12, what objects dominated the logos of the former Geological Society of New Zealand, New Zealand Geophysical Society and New Zealand Geochemical and Mineralogical Society?

Quiz answers

1) glass from the 1945 Trinity Atomic Bomb test site in New Mexico. 2) KREEP = potassium, rare earth element, phosphorus, referring to lunar basalts with high concentrations of these elements. 3) Geological Society = Monotis fossil and a geological hammer, Geophysical Society = some 2D sine-like waves within a circle and the Southern Cross constellation. NZGeMS=a tetragonal bipyramid crystal, the top part being a schematic volcano, and the lower part enclosing a magma chamber.

Popup gapfiller from Newsletter #86, 1989, p14.

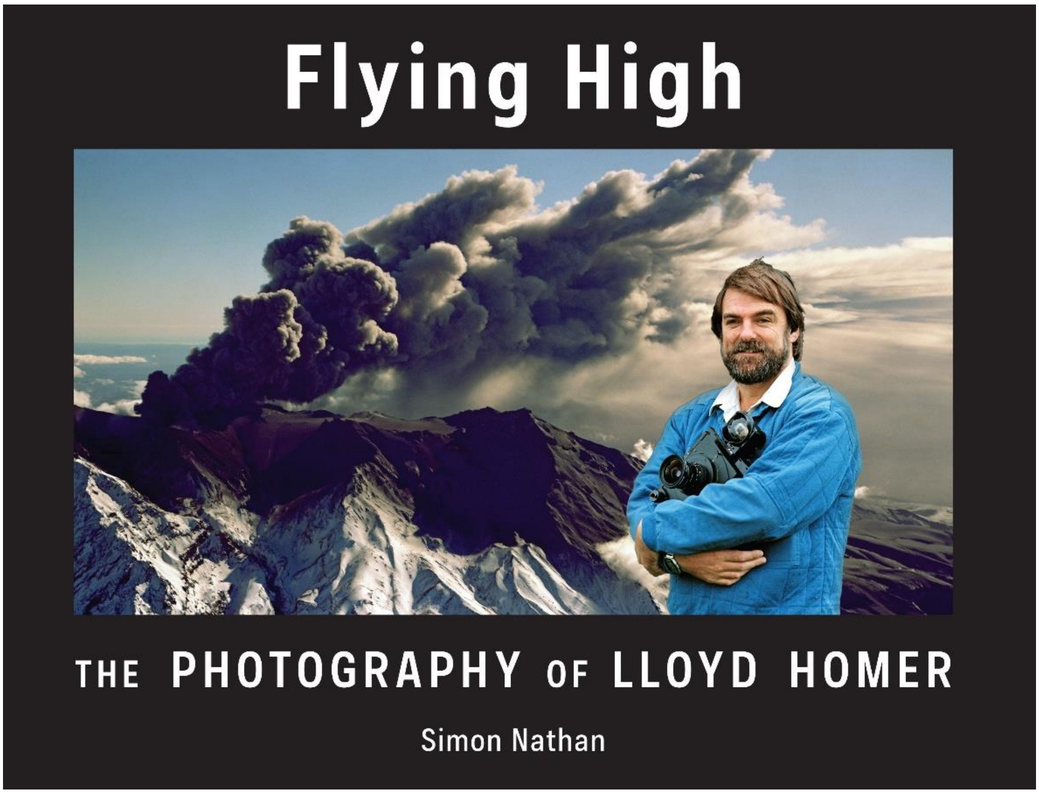
Flying high: the photography of Lloyd Homer

By Simon Nathan

Published by the Geoscience Society of NZ, 2019

148 pages, $45

Reviewed by John Rhodes



This book brings together two luminaries of New Zealand geology.

Simon Nathan's phenomenally productive retirement from his long career with the Geological Survey and GNS Science has given us biographies of Harold Wellman and James Hector, as well as a book on the photography of miner Joseph Divis. And if that weren't enough, he's also co-authored the memoirs of Brian Mason and Max Gage.

Simon's latest book celebrates the work of another luminary, whose photographs have illustrated scores of geological and other publications. When it arrived, my wife Ann (with no great interest in matters geological) picked it up and said, 'A few years ago that was a household name!' Our son visited soon afterwards and couldn't put the book down.

The name in question is that of Lloyd Homer, who over 32 years in NZGS and GNS created a body of photographic work unparallelled in New Zealand. *Flying high* gives a taste of this achievement. The book owes its broad appeal to Lloyd never having been content with mere outcrop shots but always seeking the wide picture. Today such images are made from helicopters and drones, but Lloyd took his thousands of oblique aerial shots mainly from a high-wing Cessna. He shot with the door off and muffled against the cold, using a large-format camera while an equally cold helper reloaded the next one ready for action.

The results, filed by region, used to be available for perusal at the Survey by anyone interested and found their way into hundreds of publications. Many have since been digitised, including several thousand taken by Lloyd, and can be viewed and ordered on line from the GNS Visual Media Library, at http://vml.gns.cri.nz The oblique aerial shot became—or Lloyd made it—his niche; and wherever a good photograph of the kind was needed it was his by-line that appeared. Scores appear in *Te Ara*, the on-line encyclopaedia of New Zealand.

A pinnacle of Lloyd Homer's career was the publication in 1988 with Les Molloy of *The Fold of the Land*, a sumptuous celebration of our national parks in a way that they can never be appreciated from the ground. Some of the images appear again in *Flying High*.

Through May and June of this year an exhibition in Upper Hutt—Lloyd's home turf—show-cased some of his work. This book, a permanent record, shows a range of accomplishment far wider than aerial photography. For example, it includes two technically and emotionally superb photographs of Sheryl, Lloyd's wife of 50 years, who for the last decade has been at his side in the aftermath of a serious mountain-biking accident.

The embarrassment of riches that faced Simon Nathan when he embarked on this project caused heart-rending decisions about what to leave out and how to structure the content. The resulting distillation gives 16 chapters that re-create (in necessarily abbreviated form) the highlights of Lloyd's working life, starting with several pages of black and white photography. There's just enough text to give a feeling for his career, while the photos themselves take the precedence that is their due. The stunningly effective cover shows Ruapehu at full blast with a young Lloyd Homer cradling his camera in the foreground.

I found the pictures of geologists at work—some now departed—particularly interesting and a reminder that Lloyd was no solo operator. He worked closely with others to produce the results they needed. It was a service role, but he elevated it to a profession in its own right.

Lloyd started working for the Survey as a draughtsman in 1959. He found the work tedious but, with an interest in photography, soon won a position as assistant to NZGS photographer Nat Beatus. This was the beginning of a life of which he says, 'Photographing our extraordinary, diverse landscape has always been more than just a job for me'.

If this review fails to convince you to buy *Flying high*, Google ‘YouTube Lloyd Homer’ for a video or put ‘Lloyd Homer’ in the search box at the Radio NZ website to hear a conversation about the book between Simon Nathan and Bryan Crump.

Get three or four copies; they’ll make great gifts!

Llyod Homer taking photos through an open door of a Cessna high wing (Image: Alan Knowles).

The committee consists of Ian Smith (Conference Convenor), Alan Mason and Jill Kenny (Secretaries), Barry Brennan, Sue Courtney, Mike Isaac, Corinne Locke, Richard Ruddock, Bernhard Spörli.

NEW SEDIMENTOLOGY LECTURER AT UNIVERSITY OF WAIKATO

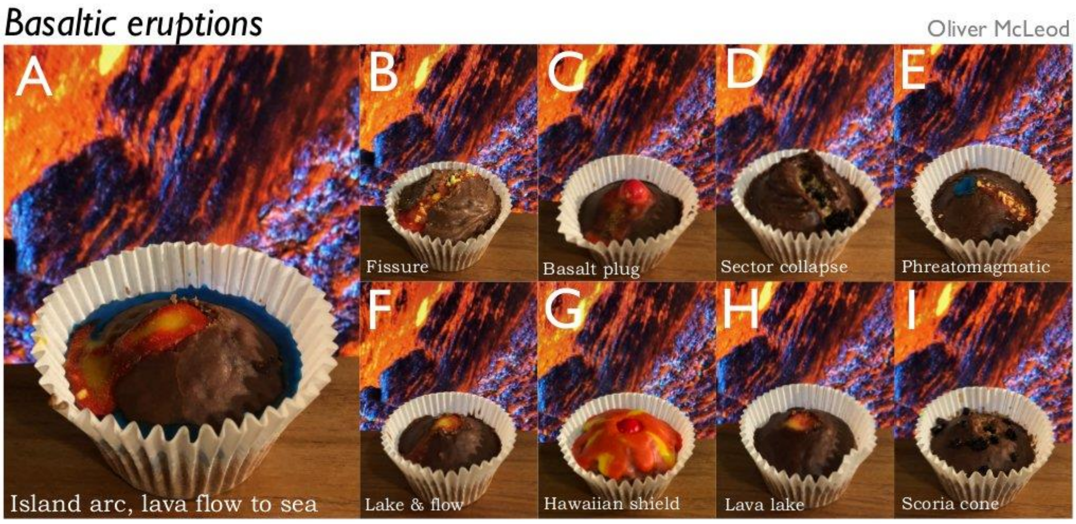
Andrew La Croix began as a new Lecturer in Sedimentology at the University of Waikato in July 2019. Originally from Canada, he arrived by way of Brisbane, Australia, where he was a Postdoctoral Research Fellow at the University of Queensland. There he undertook industry-centric research into carbon capture and storage in the Surat Basin, working to develop a new geological framework and static reservoir models for improved simulation of notional carbon injection. Prior to his time in Australia, Andrew completed his B.Sc. and Ph.D. at Simon Fraser University, and his M.Sc. at the University of Alberta. He also worked for a short time in the energy industry, and led industry field trips examining modern depositional environments.

Andrew's research interests revolve around detailed sedimentological-ichnological facies analysis and sequence stratigraphic studies, with a focus on real-world application. He is especially interested in understanding the processes operating and depositional response within modern sedimentary environments to build analogues for the stratigraphic record. With the help of his postgraduate students, Andrew is currently investigating estuaries on New Zealand's North Island to unravel the complexities of dynamic mud deposition. He is actively seeking new students and collaboration with other researchers in New Zealand. Don't hesitate to contact him if you'd like to find out more information.

Hector Day Geobake 2019

For the second year running a Geobake competition was held to bring the geoscience community together socially at cake admiration and consumption events around the country. Photos of the magnificent efforts were posted on the GSNZ facebook page https://www.facebook.com/GeoSocNZ/ for voting and the winning baker, Oliver McLeod from the University of Waikato, awarded a Geoscience Prize Pack of a year's free GSNZ membership, a geological hammer and a copy of Continent on the Move. Oliver's winning effort is shown below:

Efforts showed a huge about of creativity and commitment and the full range of entries is shown below.



Basaltic volcanism styles, as observed on the recently studied Pirongia Volcano. It is an arc volcano; originally perhaps an island or coastal, formed by initial phreatomagmatic activity, followed by multi-stage shield building with lava lakes and domes. The edifice was broadened by flank fissures and scoria cones over 1 Ma.

PUKEKO SOUP

The pukeko may only be taken in season, see N/L 63.

1 pukeko
2 cloves garlic
½ teaspoon cinnamon
1 teaspoon mixed herbs
2 cloves
1 sprig parsley
8 peppercorns
1 large onion
3 medium carrots
2 stalks celery
50 g uncooked rice
salt and pepper
dash sherry or bitters
1 small, rounded, greywacke boulder.

Skin pukeko and retain only the leg and breast meat. Tenderise with geological hammer. Place in a camp oven with one of the carrots and one of the celery stalks, garlic, herbs, cloves, parsley, and peppercorns tied in a sample bag. Cover with 10% HCL from acid bottle, bring to the boil and simmer for 3 hours, covered with a tightly fitting lid. Strain the liquid and discard vegetables and herbs (the meat may be used as a sandwich filling). Add onion and the remaining carrot and celery stalk, all finely chopped. Season to taste, add rice and cook until tender.

Serve with croutons.

Serves 6. Then throw whole lot out and eat boulder. - Anonymous

[Dedicated to all those who took Bill Watters' letter seriously - Ed.]

Upper left: Baked Vertical Section of North Otago

A pancake Haast Schist basement is overlain unconformably by the biscuit-and-custard Taratu Formation (with Oreo coal seams), followed by the sponge cake mudstones of the Katiki and Abbotsford Formations, Maltester pillow basalts of the Waiareka-Deborah Volcanics, and topped off with Ototara Limestone meringue. *Hectors dolphin and little blue penguin not to scale.

Baker: Sophie Briggs, University of Otago

Upper centre: Geocakes

Geodes occur when hydrothermal fluids passing through igneous rocks, precipitating varieties of quartz within large vesicles. The three varieties of quartz pictured are: Rose quartz, Blue quartz and Prasiolite. These geodes consist of a chocolate fudge cake contained within a dark chocolate shell and lined with vanilla frosting and sugar crystals.

Baker: Marlena Prentice, University of Waikato

Upper right: The winning entry
Middle left: Geophysical independent field studies project.
On top, you can see the RV Polaris II research vessel conducting a seismic survey to create a map to be able to investigate geophysical characterisation of near-shelf stratigraphy, as well as free-gas accumulates, along the Canterbury Margin. The cross-section shows the reflected waves off the many unconformities and the erosional surfaces below the seafloor.

Baker: Tayla Hill, University of Otago

Middle centre: Hikurangi core sample from an IODP Expedition.
Layers include 'rice crispy treat' pumice, graded chocolate sprinkle Bouma sequence representing the Kaikoura Turbidite, and layers of cake representing variations in sediment sources.
Baking Team: California State University Northridge (CSUN) Geology Graduate Students
Alison Franco, Hanah Sloan, Rachel Hohn, Anthony Downey
Middle right: Tokarahi Sill in the Vanished World neat Oamaru.
Fudge basalt columns that flowed like pahoehoe before crystallising, surrounded by lush verdant green sponge cake vegetation and little white flowers of puffed amaranth grains.

Baker: Jenny Nichols
Lower left: Gold mining

Gold has long been a highly valued commodity, as it is a rare metal and has a wide variety of uses. Native gold often occurs with silver in quartz lodes, and can be extracted through open-cast mining

Baker: Kirsty Vincent, University of Waikato
Lower centre: he Alpine Fault at Gaunt Creek (or if you really like the pillow basalts at Muriwai)

Baker: Jennifer Eccles, GSNZ President and ineligible for the prize anyway!
Lower right: Stromatolite formation from Hamelin Pool, Western Australia.
Stromatolites form when sand and calcium carbonate are incorporated into a microbial mat. They are estimated to be >3.7 million years old. These living fossils continue to record our geological history growing up to 0.3mm per year. Globally, stromatolites represent some of the earliest fossil evidence of life on Earth.

Baker: Alexis Marshall on behalf of the Thermophile Research Unit, University of Waikato.

Otago University Doctoral theses

Stephen Read stephen.read@otago.ac.nz

Verolino, Andrea

Surtseyan volcanism: case studies from Pahvant Butte and Black Point, Western USA.
Supervisor: White, J.D.L.
Shallow to emergent basaltic subaqueous explosive eruptions, here referred as Surtseyan, are a source of pyroclastic material expelled from subaqueous vents and transferred to the water column and atmosphere. They can threaten coastal communities in diff

Cole, Rosemary
Andesitic glaciovolcanic interactions at Tongariro and Ruapehu volcanoes, New Zealand
Superviors: White, J.D.L., Leonard, G., Townsend, D., Ohneiser, C.
Glaciers that cap or flank volcanoes have a major control on the eruption style and distribution of volcanic material. Ancient deposits that were formed by the interaction of lava and ice inform our understanding of glaciovolcanic eruption dynamics, as w

Tarling, Matthew S.
The structure, petrology and mechanics of a plate-boundary-scale serpentinite shear zone: The Livingstone fault, New Zealand
Superviors: Smith, S.A.F, |Scott, J.M.
Serpentinite-bearing shear zones are important in a range of tectonic settings, including the slab-mantle interface, oceanic detachment faults, and large-displacement transform faults in the oceanic and continental lithosphere. Despite abundant informati

Kirilova, Martina
The effects of graphite and porosity on the mechanics of the Alpine Fault, New Zealand
Supervisor: Toy, V.
New Zealand’s Alpine Fault is a major crustal-scale structure that accommodates around 75% of relative Australian-Pacific plate motion. This active transform fault ruptures in a large earthquake every 291 ± 23 years, most recently in 1717. This means, th

Giacalone, Emanuele
Swinburn Volcanic Complex, Central Otago, New Zealand
Supervisors: White, J.D.L., Scott, J.M.
Swinburn Volcanic Complex is the remnant of a Miocene volcano, forming part of the Dunedin Volcanic Group (~ 24 - 9Ma), on the South Island of New Zealand. It is part of the Waipiata Volcanic Field, and its basalts are distinct from most others in that f

Kerr, Gemma
Mobilisation of arsenic, antimony, and gold in redox-dynamic settings, South Island, New Zealand.
Supervisors: M Craw, D., Pope, J.

The elements arsenic (As) and antimony (Sb) are commonly enriched in mesothermal gold deposits and predominantly occur as the sulfide minerals arsenopyrite and stibnite, respectively. In such deposits, these sulfides can be important carriers of nanopart

Murch, Arran

Ash Generation in the 2012 Eruption of Havre Volcano, Kermadec Arc: The Largest Deep Subaqueous Eruption of the Last Century.

Supervisors: White, J.D.L., Carey, R.J.

The 2012 silicic eruption at Havre volcano, in the Kermadec Arc, was the largest deep subaqueous eruption observed in the last century. A data set of unprecedented richness was collected during a dedicated research cruise in 2015, including detailed bath

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Characteristics and origin of hydrothermal pebble dykes and associated host rock alteration on the Thames Coast, Coromandel Volcanic Zone

Holly Harvey-Wishart

Department of Earth and Ocean Sciences, University of Waikato

During the Miocene to early Pliocene (c. 18 Ma to 2 Ma), subduction-related volcanism migrated down the Coromandel Peninsula forming the Coromandel Volcanic Zone. This period resulted in the development of extensive hydrothermal systems which interacted with the associated volcanic sequences, the Coromandel Group andesites and dacites. As well as introducing extensive alteration and epithermal Au-Ag deposits, the active environment resulted in the emplacement of co-hydrothermal pebble dyke units. Examples of these features have been identified on the Coromandel west coast, exposed as bodies of fractured rock material, hosting well-rounded clasts due to milling during transport forming “pebbles” (Fig.1). This material has been incorporated from a variety of lithologies from different stratigraphic depths, providing a ground surface expression of the subsurface. As the formation of these dykes is not well-defined, whether they are a result of volcanic or hydrothermal activity, the aim of this study was to investigate their origin and the influence they may have had on the character of proximal hydrothermal alteration.

Fig.1: Surface exposure of pebble dyke unit within the field site located within the Thames coast study site.

Commencing mid-2018, the project involved a combination of field descriptions, optical petrology, SEM, XRD, XRF and ICP-MS geochemistry for investigating the study site along the Thames coastline, where two clusters of dykes are exposed within a ~ 600 m span of beach. The extent of the site hosts multiple alteration zones, recognised as propylitic and phyllic alteration associated with periods of mineralisation, and supergene argillic overprinting. The gangue mineralogy also mirrors the character of the broader system, reflecting near-neutral fluids associated with the low-sulfidation epithermal environment at temperatures of ~ 240 – 260 °C.

Characteristics of dyke morphologies, clast lithologies and morphologies, and alteration character suggest fluidisation played a large role, particularly so in the transport of fragmented rock material from depth. The extent of their ascent is best reflected by the occurrences of greywacke argillite and sandstone components found in each of the exposures. These lithologies are sourced from the Manaia Hill group of the Waipapa Terrane, a deep basement unit recognised as the basement rock of New Zealand. Therefore, the presence of greywacke and argillite clasts suggested possible significant depths of material transport and the interaction with high volumes of hydrothermal solutions. However, from observations of alteration style and morphologies of clasts, it appears more likely they originated from similar depths as the local volcanic stratigraphy. This may have arisen due to faulting in the region, which has also created a greywacke outcrop within the field site.

Although with the completion of the research project, the Thames coast pebble dykes have not been linked to having had direct interaction with ore-bearing fluids in the system, these features in similar systems may still represent possible mineralisation vectors due to the permeability they offer. If pebble dykes were to act as permeable pathways for ore-bearing solutions within a hydrothermal system, it is possible they could play a significant role in the concentration of metals in economically viable quantities. Therefore, under the right circumstances; emplacement during or pre-mineralisation, orientated preferential to fluid flow direction and hosted within otherwise impermeable host rock, they could yet act as a vector towards potential mineralisation.

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Young Researcher Travel Grant (YRTG) Report

EAGE Petroleum Geostatistics conference that I attended as I was awarded a Young Reasercher Travel Grant from GSNZ.

Francesco Turco University of Otago

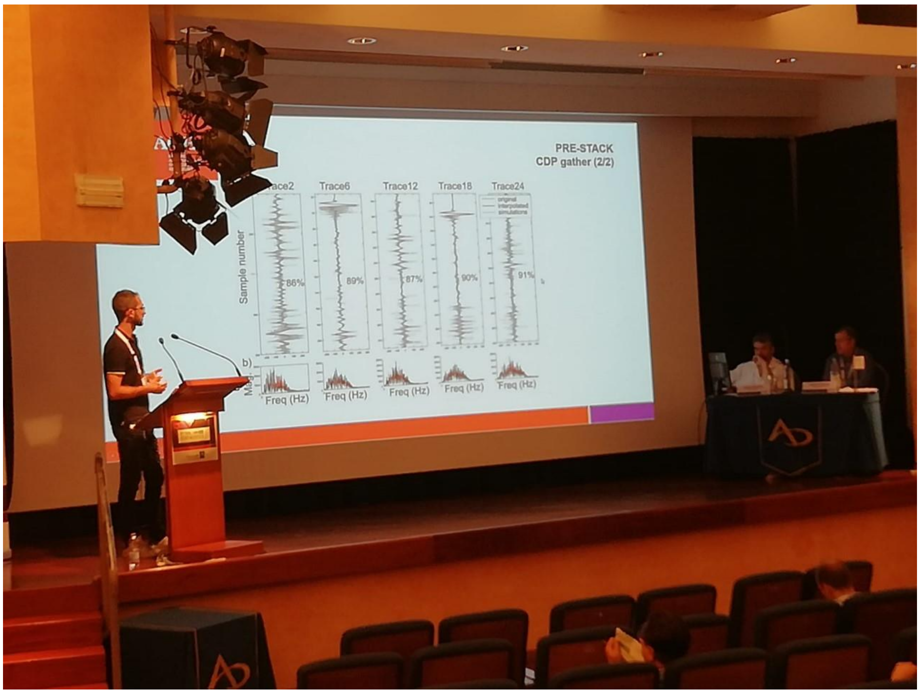
Thanks to the Young Researcher Travel Grant of GSNZ I could attend the 4th edition of Petroleum Geostatistics organzied by EAGE (European Association of Geoscientists and Engineers) in Florence. This was the first time that I attended a conference overseas, and by chance it was held in my home country. The location was amazing and the venue was only 200 meters from the famous Brunelleschi's masterpiece, the Florence cathedral.

On the first day, the chair of the conference displayed a map of the world on the screen showing where all the participants came from. There was a small red “1” on top of New Zealand, and that gave me a strange but positive feeling of representing Aotearoa at a European conference.
Over 150 people attended this conference, and I was not expecting to meet so many people with different scientific backgrounds (there were mathematicians, statisticians, reservoir engineers, geophysicists, geologists, physicists, professionals from the industry, independent consultants etc.) and it was very interesting to meet other young scientists and professionals from all the 5 continents!

The sessions of the conference were focused on the applications of geostatistics, inversion of seismic data, reservoir characterization, uncertainty quantification and even some hard core mathematics (this was usually presented by Norwegian researchers). Even though I can't say I always understood what people were presenting, I definetly got some precious hints for the development of my PhD project on gas hydrate characterization.
My talk was scheduled to be the last talk of the conference, so I had plenty of time to feel anxious (it is always scary to present in front of 150 very clever people), but this also helped me to better understand the type of audience and adapt my presentation in order to make it clearer for everybody. Despite being

very nervous at the beginning, my presentation went smoothly and I received very good feedbacks and a lot of questions.

I particularly liked the relaxed yet constructive vibe of the conference. During the coffee breaks and lunches I had the opportunity to meet people who were interested in my work and whose work I was interested in. I am really looking forward to attending the next conference in 4 years, to present some results from my PhD project.



Hastie Award MSc Progress Report

Hannah Walters   Massey University

Msc Thesis: The dynamics and stability of large Plinian plumes- A type example from the 232AD Hatepe Plinian eruption in Taupo, New Zealand.

The Taupo Volcanic Zone in New Zealand is an onshore volcanic graben, and is one of the most frequent producers of Plinian eruptions globally. Plinian eruptions, specifically those of similar magnitude to events produced by the Taupo volcano, are of great interest due to their widespread and potentially catastrophic hazard impacts. They can involve up to c. ten cubic kilometres of ejected magma that lead to, strong atmospheric disturbances during plume dispersal and extensive coarse-grained fall deposits on the ground. The dispersal and sedimentation of pyroclasts in Plinian eruptions pose significant environmental and societal threats with immediate and short-term effects on aviation and general public safety, infrastructure stability and water resources, while longer term effects include increased flood risk and impacts to agriculture. Moreover, Plinian eruptions are notorious for producing violent pyroclastic flows. The deposits of past Plinian eruptions may offer valuable insights to help preparing and mitigating for future high-magnitude eruptions here in New Zealand and elsewhere. However, this requires establishing quantitative relationships between the dynamics and stability of Plinian eruption plumes and the characteristics of their resulting deposits.

This project will test new field and laboratory techniques of characterising vertical and lateral Plinian fall sequences taking the 232 AD Hatepe Plinian eruption as a case study. The objectives of this research include: (i) establish quantitative markers for synchronous deposition laterally across fall deposits to investigate lateral variation on plume sedimentation; (ii) use this technique to ‘time’ processes of plume instability and pyroclastic flow generation; and (iii) generate from field data robust input and boundary conditions that can be used in future computational multiphase plume models. It is hoped that the systematic field and laboratory investigation will also shed new light on the complexity on one of the most iconic Plinian deposits worldwide.

Currently a few months into the research portion of my MSc, I have focussed predominantly on literature review and observations in the field to refine areas of significant interest to this project. Through use of existing isopach and isopleth data, I have defined uniform transects parallel and lateral to the volcanic plume spreading axis in order to obtain a reliable set of samples for this research. The samples I have collected have been taken vertically through the layers observed in the deposit so as to ascertain the variation of grainsize and componentry within the deposit. Using a combination of wet and dry sieving to process the samples allows me to carefully separate the grains into specific size classes which will ultimately produce grain size distribution information and allow for further analysis of the various components in the samples.

Figure 1 (left) Samples being collected at the Taupo 232AD type section. (right) Sampling a proximal Hatepe Plinian Deposit, Taupo 232AD. Photos

Further analysis will be required in order to produce a comprehensive explanation of the eruption plume dynamics in relation to how the plume spreads, with focus on the variation of components throughout the deposit. The next step of my research will consist of scanning electron microscope (SEM) imaging, density analysis of the deposit, and analysing mass and area data obtained in numerical models as a function of stratigraphic height.

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The applications and limitations of hyperspectral mapping of alteration in volcanic environments

Abbey Douglas – Department of Geology, University of Canterbury
Supervisors: Ben Kennedy, Lauren Schaefer, and Gabor Kereszturi

The absorption features of minerals in hyperspectral data are unique, making accurate mineral identification possible through spectroscopy (Clark et al., 1990; van der Meer., 2004; Kruse et al., 2012; etc.). However, it is unknown how accurate hyperspectral mapping can be for resolving alteration mineral compositions at the resolution required to describe structures such as intrusive systems a few tens of metres wide, or whether it can accurately quantify the alteration present. For this study, airborne hyperspectral data will be analysed for an exposed intrusive system, Pinnacle Ridge. This ridge is located on the northern flanks of Mt Ruapehu, in the south region of the Taupo Volcanic Zone (TVZ), and contains varying levels of hydrothermal alteration (Figure 1a; Mordensky et al., 2018). It is largely comprised of Te Herenga breccias, lava flow deposits, and dike intrusions and was exposed by glacial erosion and sector collapse (Hackett, 1985). The internal plumbing system of young volcanoes are typically not exposed; therefore, Pinnacle Ridge is a unique opportunity to investigate volcanic processes internal to the volcano.

To assess what spatial and spectral resolutions are needed to identify alteration minerals with hyperspectral data, two scales have been analysed. The first scale is laboratory spectroscopic data, which has a spatial footprint of 10 mm and a spectral resolution of 1 nm, measured on hand samples. The second scale is aerial data with a ground footprint of 1.5 m with a spectral resolution of 3-10 nm. Field work on Pinnacle Ridge was completed to collect hand samples from each unit with supplementary samples provided by Stan Mordensky from his PhD in 2019. Spectroscopic data for all hand samples has been collected and processed at Massey University by Gabor Kereszturi. The aerial hyperspectral data was also provided by Kereszturi from his Natural Hazards Research Platform (NHRP) project with Lauren Schaefer and Ben Kennedy. The degree of alteration in each sample was quantified using point counting, a statistical method of estimating the proportion of different mineral occurrences in a thin section slide. This method was validated by X-ray diffraction (XRD) analysis on a few of the samples which showed the accuracy of point counting to be within XRD uncertainties. The results of the point counting show the range of alteration on the ridge to be 7.6-85.2% (Figure 1b), making it an ideal candidate for this type of analysis. Six alteration groups were created from this data, which are currently being used to compare to the laboratory spectroscopic readings. The hypothesis for the laboratory data is that the samples with a higher percentage of alteration will have deeper absorption peaks at wavelengths typical of alteration minerals (van der Meer., 2004).

Yet to be completed is a comparison of the aerial data to the laboratory spectroscopic readings in order to see what is lost in the mineral signatures as the spectral and spatial resolution decreases, and to create a random forest classification of the aerial data to produce a quantitative geological map of the alteration present on Pinnacle Ridge.

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mechanical property relationships of a shallow intrusion and volcanic host rock, Pinnacle Ridge, Mt. Ruapehu, New Zealand. *Journal of Volcanology and Geothermal Research*, *359*, 1-20. https://doi.org/https://doi.org/10.1016/j.jvolgeores.2018.05.020
van der Meer, F. (2004, 2004/02/01/). Analysis of spectral absorption features in hyperspectral imagery. *International Journal of Applied Earth Observation and Geoinformation*, *5*(1), 55-68. https://doi.org/https://doi.org/10.1016/j.jag.2003.09.001

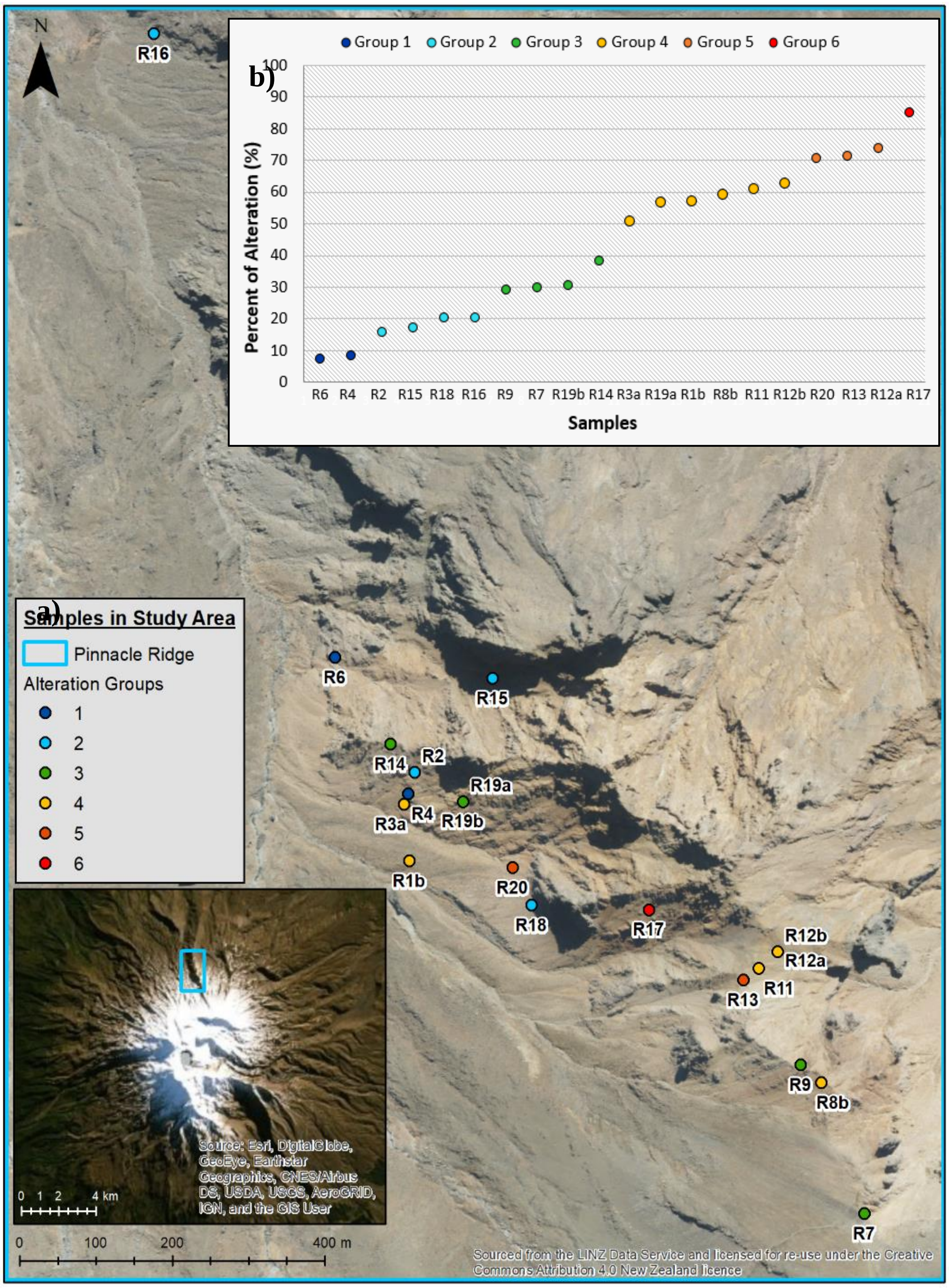

Figure 1: *a) Location of samples from Pinnacle Ridge, Ruapehu, and b) their alteration percentages from point count analysis. Map created in ArcGIS ArcMap.*

GSNZ publishes best practice guide for identifying and assessing outstanding natural features

Bruce W Hayward (for GSNZ Geoheritage Subcommittee)

Protection of outstanding natural features (ONFs) is a matter of national importance according to Section 6(b) of the Resource Management Act 1991. They are to be protected "from inappropriate subdivision, use and development". When the RMA Act was drafted the term ONF was introduced largely to cover "natural features so beautiful, unique or scientifically important that their preservation is in the national interest" (from National Parks Act, 1980) and "for the preservation and management for the benefit and enjoyment of the public, areas of New Zealand possessing … natural, scenic, … geological, scientific, educational, community or other special features of value" (from reserves Act, 1977). Unfortunately, the RMA did not include a definition of an ONF.

Over recent decades there has been a tendency for some regional and local councils, who apply the RMA, to misunderstand what ONFs were originally meant to be and to combine them with Outstanding Natural Landscapes (ONLs) as something they call ONFLs, with ONFs treated as small landscape features. In doing this the councils are ignoring the protection of their valuable geoheritage of outstanding geological sites and landforms. In an attempt to redress this trend, the Geoheritage Subcommittee of the Geosciences Society of NZ has prepared a document titled "Best Practice guide: Outstanding Natural Features
What are they and how should they be identified. How their significance might be assessed and documented?" as GSNZ Miscellaneous Publication 154, 27 p. It is free for anyone to download from the GSNZ website (http://www.gsnz.org.nz/information/misc-series-i-49.html).

As part of this initiative, copies of this Best Practice Guide, together with copies of three of GSNZ's Guidebooks (nos 12, 15, 17) that promote protection of New Zealand's geoheritage, have been sent to the CEOs and Chief Planners of all Regional and District councils in NZ. We have also requested that the Ministry of the Environment include a definition of ONFs in the RMA as part of the review currently underway. Please feel free to use this guide or to point out its existence to anyone involved in the process of identifying and assessing the importance of ONFs for councils. If you have feedback on the document please contact the Geoheritage Subcommittee.

Fig. Maungaraho dike, an Outstanding Natural feature in Kaipara District.

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What would Sir Julius von Haast think of this?

Metamorphosis of the Geology Department

As of 16th September, 2019, the Department of Geological Sciences, the Department of Geography, the Waterways Centre for Freshwater Management and Gateway Antarctica at the University of Canterbury will together become **the School of Earth and Environment | Te Kura Aronukurangi.** The existing geology degree programmes will continue and the school will also be the home of the Environmental Science degree.

EDUCATIONAL.

UNIVERSITY OF NEW ZEALAND.

CANTERBURY COLLEGE.

PROSPECTUS FOR 1877.

TIME TABLE FOR THE SESSION.

First Term—Beginning on the Second Monday in March, and ending on the Third Saturday in June.

Second Term—Beginning the Third Monday in July, and ending the second Saturday in October.

Fee for each course of Lectures of two hours a week, One Guinea for each term; for a course of one hour a week, Half-a-guinea. Ladies are admitted as students to all the classes.

Students are required to enter their names with the Registrar at the Public Library before commencing attendance at the Lectures. Morning Lectures will be substituted for those given in the evening, as soon as found practicable.

A Course of Six Lectures on the Useful Metals—Thursday, 8 p.m., 5s.

A School Class—Twelve Lectures on Sound, Light, and Heat—Thursday, 4 to 5 p.m.

GEOLOGY.

Professor Julius Von Haast, Ph. D., F.R.S.
Lecture—Tuesday and Friday, 4 to 5 p.m.

BIOLOGY.

Llewellyn Powell, M.D., F.L.S.
Botany—Thursday, 7 to 8 p.m.; Saturday, 12 to 1 p.m.
Botany (Elementary)—Friday, 4 to 5 p.m.
Zoology—Wednesday and Friday, 6 to 7 p.m.

FRENCH.

Rev C. Turrell, M.A.
Lecture—Tuesday and Saturday, 6 to 7 p.m.

GERMAN.

Rev C. Turrell, M.A.
Lecture—Tuesday and Saturday, 7 to 8 p.m.

JURISPRUDENCE.

C. J. Foster, L.L.D., and Member of Senate of University of London.
Lecture—Wednesday and Thursday, 9 to 10 a.m.

From Paperspast: Timaru Herald. Vol. XVII (1645) February 5, 1877.

Retirement of Daphne Lee

Bruce W Hayward and Ewan Fordyce

Daphne at work in the lab (Image: Ewan Fordyce)

Assoc-Prof Daphne Lee recently retired from employment in the Geology Department of Otago University although she retains ties as an Honorary Associate Professor. Daphne has had an illustrious and increasingly public career in New Zealand paleontological research but additionally she has also played major roles in university teaching and in the promotion of geological education in schools.

Daphne gained a BSc (Hons) at Otago in 1972 and her PhD, also from Otago, with a thesis on Cenozoic and Recent rhynchonellid brachiopods of New Zealand. As a young mother, Daphne continued her research part-time on fossil and living brachiopods for many years. This culminated in her being invited to be the co-ordinating senior author and major contributor for the Order Terebratulida in the global treatise on Brachiopoda (Lee et al., 2006). This has become the essential international reference work for brachiopod systematics and paleoecology and will remain so for many more decades. In this undertaking she co-ordinated and brought together the contributions from an international team of brachiopod experts from New Zealand, United Kingdom, USA, China and Russia. Their 300-page section of the Treatise provides systematic descriptions and illustrations of more than 660 living and fossil terebratulid brachiopod genera.

After graduating with her PhD in 1981 (her husband, Bill graduated with his PhD in Botany in the same ceremony), Daphne spent a very formative 18-month period based in the Department of Earth Sciences in Cambridge, and commuting regularly to the Natural History Museum in London. Daphne formally joined the Otago University staff in 1988, the first woman to join the academic staff in the Geology Department, initially to run first-year distance teaching classes, and had a succession of part-time permanent academic positions for the next thirty years. She taught a wide diversity of courses, and has supervised many graduates undertaking their thesis research. In the 21st century Daphne's role as research leader took off as she obtained funding for, undertook, co-ordinated and supervised research on several amazingly rich and well-preserved Oligo-Miocene fossil treasure boxes that her team was uncovering in southern New Zealand. One of these localities is Foulden Maar which has become nationally-famous this year (as has Daphne) with the proposal to mine all the diatomite and ship it overseas as a stock food additive. Her Marsden-funded group have been documenting the fabulously-preserved fossil leaves, flowers (with intact pollen), whitebait, spiders and insects that have revolutionised knowledge of the history and biodiversity of New Zealand's terrestrial biota. These studies have shown that terrestrial environments in New Zealand persisted throughout the paleogeographic bottle-neck disproving the controversial hypothesis of a period of complete drowning of New Zealand.

In loosely-related marine paleontological research in Southland her team has been discovering and documenting further highly diverse and well-preserved Oligocene and Miocene rocky shore and near-shore invertebrate fossil assemblages that have helped establish the extent and location of land in southern Zealandia through the bottle-neck period. In the last 10 years Daphne has been a co-Principal Investigator for three Marsden Fund grants that have allowed her to gather a talented team of post-doctoral fellows and graduate students around her and to collaborate with many overseas paleontologists to support these major research programmes.

Through her enormous research output, particularly in the last 20 years, Daphne has become one of New Zealand's most internationally-recognised palaeontologists and paleobotanists. In 2017, her recent paleontological research as outlined above was recognised with her receiving GSNZ's McKay Hammer Award "*for the most meritorious contribution to NZ geology in 2014-2016".*

Earlier in her career, Daphne devoted over 20 years to the promotion of earth science teaching in NZ schools as Convenor of the Earth Science Education Subcommittee of the Geological Society of New Zealand (1983-2005). She became the leading authority in NZ on this topic and was largely responsible for Planet Earth and Beyond being added to the NZ School Science Curriculum in the early 1990s. In this role, and through Otago University, Daphne coordinated the production of new earth science teaching resources, compiled lists of resources for teachers, and also wrote a popular field guidebook on Central Otago rocks published in our society's guidebook series.

We all wish Daphne a long and productive retirement in research and as a doting grandmother.

Small selection of Daphne Lee's significant publications relevant to the above:

Lee, D.E., Lee, W.G., and Mortimer, N. 2001. Where and why have all the flowers gone? Depletion and turnover in the New Zealand angiosperm flora in relation to paleogeography and climate. *Australian Journal of Botany* 49: 341-356.

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Daphne and field trip participants on Geological Society field trip to Central Otago, St Bathans 2003. photo reputedly by Bruce Hayward.

Daphne and colleagues at St 2017. Back row, left to right Mathew Vanner, John Conran, Daphne Lee, Jennifer Bannister; front row left to right Ian Geary, Jon Lindqvist, Uwe Kaulfuss. (Image: Bill Lee).

David Skinner

(May, 31, 1938 - August, 14. 2019)

By Ian J Graham & Bruce W Hayward

David Skinner, who died recently at 81, made a noteworthy contribution to New Zealand and Antarctic geoscience over a fifty-year period. He was equally known for his musical talents, taking numerous leading roles in opera and musical theatre throughout New Zealand. His portrayal of Tevye in *Fiddler on the Roof*, as well as various patter roles in Gilbert & Sullivan comic operas, was legendary. He also found time in his full and busy life to act as treasurer for a number of musical and geoscience societies, most notably the Geoscience Society of New Zealand, which he served for most of the past 15 years.

David was born and raised in Seatoun, Wellington, attending Rongotai College, then Auckland Grammar School. In 1962 he completed an MSc at the University of Auckland on the geology of Moehau-Cape Colville district of northern Coromandel Peninsula. His PhD, which mapped a much larger area and emphasised the economic aspects of northern Coromandel's geology, was undertaken while employed by the NZ Geological Survey and completed in 1967 -- the first PhD in geology awarded by the University of Auckland.

Apart from Fiordland, it is hard to think of a more difficult place in New Zealand to map geologically, with rugged country, dense bush, and many weathered outcrops providing a myriad of traps for young players. On one occasion while undertaking fieldwork to produce 1:1-mile geological maps of the area, he failed to secure the handbrake on the department land rover and, to his chagrin, had to watch it slowly travel downslope and over a cliff into the sea! …with most of his gear still on board. After walking out of the bush and hitchhiking back to the office, he had to face the wrath of the Director who was none too pleased at the loss of one of the department vehicles!

Over several decades David took on the challenge of Coromandel geology, and his legacy remains to assist others to better understand this economically important part of the country. He sole-authored the geological maps for seven map sheets in the area, including the 1:1-mile map of Northern Coromandel, published in 1976, the 1:50,000 map of Coromandel Harbour, published in 1993, and the 1:50,000 map of Mercury Bay, published in 1995.

The late Fred Bowen related an occasion in the early 1970s when the co-ordinator of regional mapping in the Survey decreed that all 1:1 mile maps be mapped as whole sheets. One of these maps stretched across the Firth of Thames and included part of the Hunua Ranges that Jim Schofield was mapping and part of the Coromandel Peninsula that David was mapping. Their respective maps of the basement Waipapa Terrane greywacke on either side of the Firth were dramatically different, with Jim's mapped as a simple stratigraphic succession with repeated lithological units through time and David's more complex with numerous faults displacing one set of the same lithologic units. The two were asked to sort out their differences and come up with an agreed combined map and so they headed for a one-day visit to the Coromandel west coast with Fred Bowen along as 'referee'. Anyone who remembers the temperament of both men in their younger days can visualise how the arguments became extremely combative and heated on the outcrop with neither prepared to give an inch. The trip back to Auckland required Fred to sit between the two to prevent them coming to blows and neither would speak to the other for days afterwards. The resolution was that the two maps were published separately with the map sheet split down the middle and attached to their respective adjacent map sheets
.
David's first real job for the Survey was to map the region around the Ngawha hot springs in Northland, which included logging the first geothermal drill-hole there. This research continued through the 1970s, making a key contribution to the delineation of Ngawha's geological structure and geothermal resource. But the Coromandel kept dragging him back. By the 1980s David was recognised as the leading authority on Coromandel geology. Several important papers resulted from his research, including his 1994 co-authored paper with Chris Adams and others on the geochronology and geochemical evolution of Coromandel volcanic rocks, which has so far attracted nearly 100 citations. With Tony Christie and Bob Brathwaite he co-authored a number of papers on copper-gold mineralisation associated with the Thames and Hauraki goldfields. David's other professional focus was the geology of Antarctica. He participated in ten expeditions to the ice, often as science leader. The first in 1960-61 was a mapping expedition to the Byrd Glacier in the Transantarctic Mountains. This was followed by expeditions to Terra Nova Bay and North Victoria Land, and the Skelton and Koettlitz glacier regions of South Victoria Land. In 1979-80 he was

seconded by the DSIR to the first German Antarctic Expedition, known as GANOVEX. This led to further invitations to participate in 1982-83, 1988-89 and 1992-93, and three secondments to the German Federal Geological Survey. The final two expeditions were associated with an Italian-led science initiative - David recounted that the Italians came equipped with the latest designer gear with matching accessories, in contrast to the Germans, who were much more rough and ready (he speculated that the Survey sent him on these missions to keep an eye on what the Germans were up to in Antarctica). Many important scientific publications arose from these activities and in 1984, David was awarded the Queen's Polar Medal for his contribution to Antarctic geological research. He also had a landscape feature named after him – Skinner's Ridge. From 1962 to 1987, David was employed by the NZ Geological Survey and based in the Auckland Office at Otara. His home in Auckland boasted the entrance to Auckland's best-known lava cave (Stewarts), which must have offered an ideal bolt hole in which to do his scientific thinking. After acting for a time as District Geologist, he moved to Lower Hutt to be Assistant Director of the Geological Survey until it metamorphosed into what is now GNS Science. He retired from full time paid employment in 1997 but remained with GNS Science until very recently as a contractor and Emeritus Scientist.

David joined the newly formed Geological Society in the early 1960s, and remained active within it for more than 35 years. He was chair of the Auckland Branch in 1969 and 1975, and led many branch and conference fieldtrips, especially to the Coromandel. He also played major roles on the organizing committees of international conferences, such as the Australian and NZ Association for the Advancement of Science, in Auckland in 1979, and the International Symposium of Antarctic Earth Sciences, in Wellington in 1999. For the latter he co-edited the massive proceedings volume with co-convenors John Gamble and Stuart Henrys.

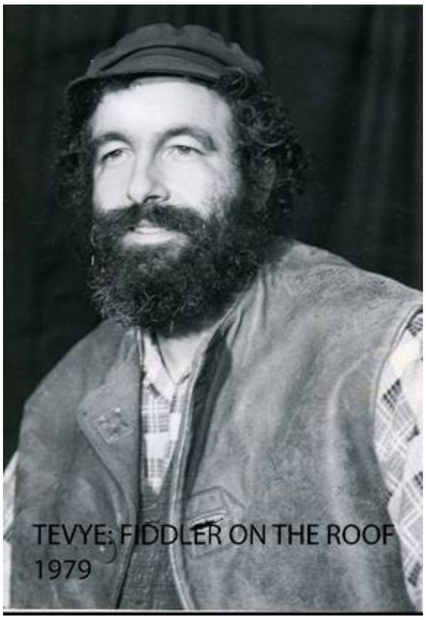
Richly deserved, David received the 2014 Honorary Membership award from the Geoscience Society of NZ for outstanding service. As its longest-serving treasurer, he ably steered the society through the complexities of incorporation, GST registration, and charitable trust tax-exemption status, as well as the amalgamation of two sister societies (the Geophysics and the Geochemical / Mineralogical societies), and the establishment of separate GSNZ Award Trust accounts. During his time he oversaw a fourfold increase in annual income, whilst allowing member subscriptions to rise only modestly.

David was a classically trained geologist, with a well-honed ability to map rocks in the field and apply petrographic techniques to determine their history and significance. Overcoming colour-blindness, which must have made mineral identification tricky at times, he used hand-specimen analysis and microscope techniques to cast light on earth processes that gave rise to various geological formations over geologic time.

Over the years David also directed his skills to the art of 'forensic geoscience', in which careful study of rocks or minerals relating to a crime scene is used to help solve the crime. Examples include the debunking of a claimed platinum

discovery in Northland in 1973 and, in 1985, helping to establish the case against the two French Agents responsible for the Rainbow Warrior bombing. For the latter, samples from a campervan thought to be used by the agents revealed rock and mineral samples identified as common or indigenous to several localities where the agents had been. One of these locations was near a beach where the boat used in the bombing had been abandoned.
Sadly, classical petrography is becoming a lost art, as geochemical black boxes for quick and easy petrological analysis take precedence. Time will tell whether this will ultimately prove to be a backward step for geology.

In 2004 when the concept of a popular science book to explain New Zealand's active and diverse geology was first mooted, David quickly became an enthusiastic supporter and contributor of ideas. Published in 2008, reprinted twice, then revised in 2015, *A Continent on the Move* has ably served its purpose in providing scientifically literate, but easily digestible, explanations of geoscientific phenomena to scientists and the general public alike. David was editor of the introductory chapter, and contributed two articles, one on forensic geoscience and one on the basement geology of Antarctica. He also contributed a chapter to the earlier NZ Geological Survey tome *The Geology of New Zealand*.



David Skinner's contribution to New Zealand and Antarctic geoscience has been significant, particularly in the areas of geological mapping and petrology, and his legacy will be appreciated for many years to come. He became the go-to person for the identification of strange and wonderful rock or mineral specimens discovered around the country, and for this service alone he will be missed. However, it is as the 'Singing Geologist' that he may be most remembered, along with his selfless service to geoscience and music organisation in New Zealand.

Some selected significant publications

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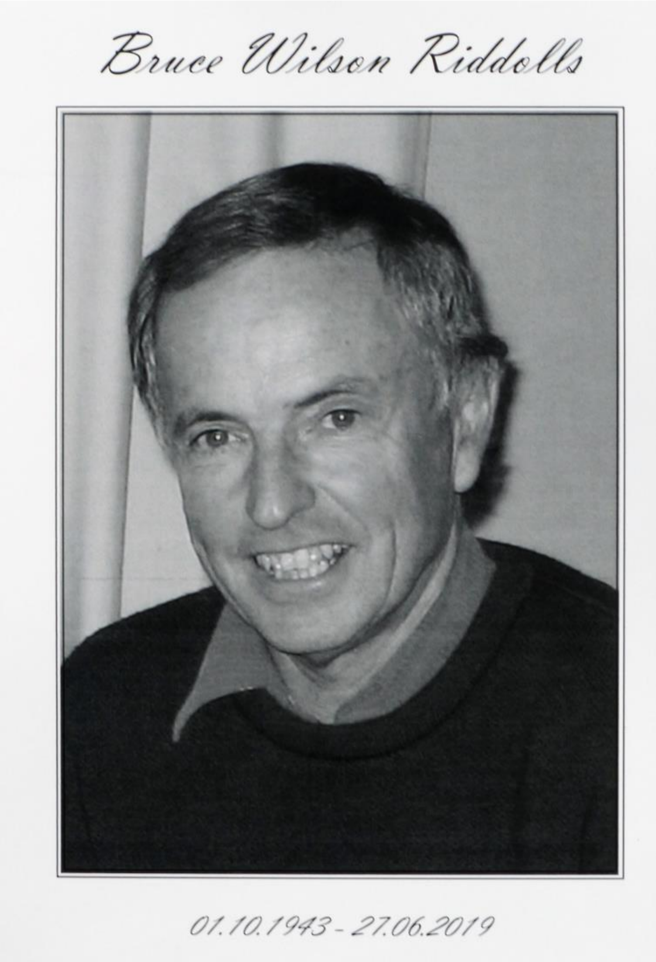
Bruce Wilson Riddolls MSc (Hons) PhD. MNZGS. MGSNZ.

(1 October 1943 – 27 June 2019)

David Hopkins with input and assistance from Ian Parton, Guy Grocott, Ian Brown, Don Macfarlane, Geoff Farquhar, Nick Perrin, Simon Nathan and Patricia Riddolls.

Pioneering Engineering Geologist



Dr Bruce Riddolls was a noted engineering geologist who played a leading role in making geological considerations an integral part of project investigations in New Zealand. Having studied regional mapping for his MSc at Canterbury University and obtaining a PhD from Exeter University on geological mapping Bruce developed a strong appreciation of the importance of geological context to the safety and viability of major engineering works. This appreciation was greatly enhanced during his ten years (1971-81) with the NZ Geological Survey (NZGS) Division of DSIR (later to become GNS Science). He joined at a time of rapid development of national infrastructure. NZGS had a long-standing role in providing geological advice to government and its Engineering Geology section grew to provide advice on hydro-electric and thermal power development, tunnelling, roading, railways and gas pipeline projects.

At a time when engineering geology was in its infancy in the private consulting engineering profession, Bruce accepted an offer from Worley Consultants (now AECOM) to establish and lead an engineering geology group. During his six years in Auckland, (1981 to 87) as Chief Engineering Geologist, Bruce carried out and led a wide range of assignments on major civil and mining engineering projects across New Zealand and overseas, including Laos, Indonesia and PNG. Engineering geology became recognised as a vital consideration on projects of any scale.

Having established his credentials in the private sector, Bruce set up his own consultancy, Riddolls Consultants Ltd with his wife Patricia, based in Queenstown. His work during that time (1987 to 89) centred on the massive challenges involved in the Clyde Dam development, not just with the dam itself but with the geographically extensive engineering impacts of the establishment of Lake Dunstan – notably the need to stabilise inundated slopes to avoid landslides which could cause overtopping of the dam. Up to 35 engineering geologists were involved and Bruce made strong contributions with his knowledge, insights and analytical skills. He stood out for his ability to visualise and conceptualise and determine the geological setting and its engineering implications. His ability to think laterally to generate bright ideas was much appreciated by his peers – though this ability could frustrate on occasion.

Having established Riddolls & Grocott with fellow engineering geologist, Guy Grocott in 1994, he moved to Christchurch in 1996. For the next four years he applied his skills and knowledge to government and private sector projects. Notable amongst a range of projects Bruce collaborated on was a 1999 report for BRANZ, *Quantitative Assessment for Determining Slope Stability Risk in the Building Industry,* which is an important reference work for practitioners still being cited in New Zealand geotechnical publications and internationally. Dr Riddolls served four years (1998-2002) as Vice President for Australasia for the International Association of Engineering Geology and the Environment, having previously served on the Management Committees of both the NZ Geotechnical Society and the NZ Society for Earthquake Engineering.

In 2000, RGL merged with Golder Associates Ltd a large international geotechnical consulting firm headquartered in Canada. Bruce's focus shifted to project reviews and management of professional services. This broadened his perspectives and experience but did not satisfy his desire to be hands-on. In 2003, with an established reputation for insightful interpretations of geological and geotechnical aspects and concise reports, Bruce re-established Riddolls Consultants to focus on geological reviews, strategies, expert evidence and mentoring. Risks from natural hazards and their implications for major engineering developments formed a strong part of his work in this period. His 2007 co-authored report for EQC, *Managing Landslip Risk – Improving Practice,* highlights Bruce's understanding of the issues and demonstrates his ability to communicate simply, clearly and succinctly.

During this time Bruce exhibited an entrepreneurial spirit. In 2005, with two colleagues, he helped form B2G Energy Ltd to explore for coal-bed methane gas. B2G Energy was granted an exploration licence in part of the Roxburgh Coal Field but the one hole that the company drilled proved barren.

A particular strength Bruce developed in later years was high-level peer review of geological modelling for major projects and in that capacity he was retained by major clients including Transit NZ (now NZ Transport Authority), KiwiRail, Wellington City Council, Canterbury Waste Services Ltd, Fulton Hogan Ltd, and the Department of Conservation.

Bruce continued to provide consulting services until very recently, moving to Auckland in 2014 and then to Pegasus in 2018 where he could once again enjoy being on the Canterbury Plains and close to the Southern Alps.

Bruce Riddolls was not just a dedicated and highly skilled professional. He was passionate about passing on his knowledge and insights and acted as mentor for many younger engineers and engineering geologists. Few people with whom he interacted would realise the breadth of his knowledge and experience or the depth of his insights. He was unassuming and not particularly assertive in putting his views forward. But he was strong-minded with a drive towards excellence in all his work. His contributions were always very much to the point and reflected his deep knowledge and understanding. One of his many qualities was brevity in report writing – if it could be stated in one page, there was no need to say it in 10.

Rarely did he mention that he had spent a season exploring remote parts of Antarctica in 1966-67 – a challenging assignment in those days which gave him the opportunity to put Mt Riddolls on the map.

Bruce recently celebrated his 50th wedding anniversary. He met his geologist wife, Patricia, while studying in Exeter. They worked at NZGS together and formed their consultancy. These common interests no doubt enabled Bruce to refine and develop his knowledge and skills. The Riddolls family, Bruce, Tricia and daughters Ellen and Frances, lived in different parts of New Zealand. Bruce was able to use his innovative DIY and other skills on a range of properties, all to good effect. He was noted for his quiet and dry sense of humour and colleagues recall several (harmless) practical jokes played on them.

Bruce played and watched cricket, golf, football, tennis and squash. He enjoyed travel, reading and listening to music. He sang in choirs and performed on stage, notably in *Hello Dolly* and Gilbert and Sullivan operas.

With his wide professional and personal experience this man of gentle spirit quickly gained and then retained the respect and admiration of his friends and colleagues who rated him amongst the best of their acquaintance. Someone it was good to spend time with. And who will be sadly missed.

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GEOSCIENCE SOCIETY OF NEW ZEALAND NEWSLETTER

EDITOR:

Glenn Vallender 16 Woodham Drive, Allenton, Ashburton 7700
ge.vallender@xtra.co.nz

DEADLINES:	**March Issue**	**February 15**
	July Issue	**June 15**
	November Issue	**October 1**

This is your newsletter and the editor seeks correspondence, news items, interim or preliminary reports of current research, reviews of books and of recent geological publications and other topical articles. Reviews of New Zealand geology, geochemistry and geophysics published overseas are particularly welcome.

We suggest a limit of 1000 words or one to four pages in the current format for most contributions with minimal but key referencing. Depending on space, longer articles suitable as feature articles with illustrations are often published.

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