# NEWSLETTER

Geoscience Society of New Zealand

Front Graphic:
Waipounamu erosion surface SH87
(Glenn Vallender)

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# GEOSCIENCE SOCIETY OF NEW ZEALAND

*A member body of the Royal Society of New Zealand*

Mailing address: P.O. Box 7003 Newtown, Wellington, 6242

PRESIDENT: **Jennifer Eccles**, School of Environment, Auckland University
j.eccles@auckland.ac.nz

VICE-PRESIDENT: **James Scott** james.scott@otago.ac.nz

IMMEDIATE
PAST PRESIDENT: **Adrian Pittari**, Department of Geology, University of Waikato, Hamilton.
apittari@waikato.ac.nz

SECRETARY: **Richard Wysoczanski** Richard.Wysoscanski@niwa.co.nz

TREASURER: **Alan Orpin** Alan.Orpin@niwa.co.nz

ADMINISTRATOR: **Nicki Sayers**, Geoscience Society of New Zealand,
PO Box 7003, Newtown, Wellington, 6242. admin@gsnz.org.nz

**Please contact administrator regarding membership, subscriptions or publications**

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**Kate Akers** Massey University, Palmerston North

NEWSLETTER EDITOR:
**Glenn Vallender**, 16 Woodham Drive, Ashburton, 7700 ge.vallender@xtra.co.nz

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# GEOSCIENCE SOCIETY OF NEW ZEALAND

## 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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**Contents**

## FROM THE PRESIDENT


Jennifer Eccles

If I've been feeling a little 'Foulden-jacked' over the last few weeks. I can only imagine what Daphne Lee and Bruce Hayward have been feeling as the admittedly largely Otago-centred media storm refuses to abate over proposed mining at the early Miocene Foulden Maar diatomite deposit near Middlemarch with its valuable climatic record and spectacular fossil preservation. The interest has been heartening, speaking to the engagement of public with geoscience on this issue. While such furores are thankfully few and far between this situation has underlined to me the real importance of having a society with members with the foresight to create an inventory of (geo)scientifically significant sites and the standing to command respect and a hearing as to how we should manage human activities impinging on these. However, it has exposed that there is constant ongoing work required to make sure all regulatory bodies and the public recognise the geoscience related 'Outstanding Natural Features'. That we are not a fundamentally anti-mining/development group is a point I have often found myself stressing over the last few weeks but 'value' comes in many forms other than the dollar and proposals (or Overseas Investment Office decisions or Resource Management Act consents) should be judged and managed with all the facts on the table. Today I have been asked what the feeling within the society is about mining at Foulden and the truth is I don't know all of your minds but my response has typically been to say bimodal – the idealistic and the pragmatic. The society's official position has traditionally been, and continues, to take a pragmatic approach to Geoheritage matters to protect the critical features while working with industry constructively where we can. Any official submissions made are objective and science based. My gratitude goes to Bruce Hayward and the geoheritage subcommittee for their long-term commitment to this space.

At this point I have given my President's lecture to the Auckland, Wellington, Manawatu and Waikato branches with others to come shortly and it has been great to meet more of the community. One question I've taken on the road is what people want from our website which is currently under redevelopment. The archival aspect is something you need not fear will be lost. We will be making key information more visible and improving the website functionality and searchability. Better integration of the website and membership management software should reduce bugs in joining or renewing. Some feedback from those I've talked to so far is that we don't need to be investing in the development of new public-targeted content but instead could provide a better guide and links for navigating to content or functionality already hosted elsewhere. If you haven't been able to have your thoughts heard yet feel free to contact me directly by email or discuss your thoughts with your local representative on the national GSNZ committee. Long serving webmaster Hugh Grenfell is stepping down with the redevelopment.

The new website will come within the purview of the communications subcommittee of the national committee and operationally keeping ontop of content updates in the post-development phase likely to fall to administrator Nicki Sayers who already sits at the hub of much of the flow of information. We would like to thank Hugh for his long-term contribution to the society in the webmaster role. Facebook is a more polarising forum but can facilitate the real time interactions and flow of information that younger members in particular may desire. I'd like to acknowledge the invaluable efforts of Helen Bostock, and Kat Holt before her, in keeping the GSNZ feed topical and lively. Helen soon leaves us for Australia and I would encourage those of you who do use facebook to apply to join the **"GSNZ Discussions"** group you will find on our facebook page https://www.facebook.com/GeoSocNZ/ as we trial a model where the wider membership themselves can contribute (relevant) content more easily.

## EDITORIAL


Glenn Vallender

Firstly, a big thank you to all the contributors to this issue. It was not that long ago when this issue would have been a ten pager. In response to the call for an update on student thesis research you will see that Canterbury University has had a number of students complete their PhD theses. This raises the interesting issue of whether to embargo a thesis or not and even the wider issue of 'open access' to academic peer reviewed research findings: two related but quite different issues. A recent list of open access by the Taylor and Francis publishing company is interesting to read (https://www.tandfonline.com/openaccess/openjournals). It is not surprising that the 'Canterbury earthquakes' has spawned a larger number of theses where social science meets geoscience http://dissertationreviews.org/archives/11995 and where that word 'resilience' dominates discussion. It is great to be able to read what geology students are researching in 2019 – quite dfferent to 1970! According to the Times Higher Education, (https://www.timeshighereducation.com/news/phd-completion-rates-2013/2006040.article#survey-answer) 73% of 11,625 students completed their PhD within seven years. Interestingly, in NZ in 2003, (data is a bit old), around 65% of the Doctoral cohort were actually employed in NZ four years after they last studied https://www.educationcounts.govt.nz/publications/80898/do-people-with-doctoral-degrees-get-jobs-in-nz-post-study). Furthermore, *"the domestic employment rate of the New Zealand doctoral cohort was lower than in similar leaving cohorts in Canada and the United Kingdom".* Nearly all universities imply in their adverts that they are the number one place to be to undertake a PhD! I wonder where this year's crop of graduates will be in 15 years time?

According to some, producing a Newsletter is a waste of time because you don't get that 'instant feedback' from Society members via 'social media' interaction - where opinion rules and 'evidence' is not necessary. What's more, Newletters are 'stuck in the first decade of the 21st century' and no longer cut the mustard being slow, expensive and cumbersome. Survey data from GSNZ members (NL27, March 2019, p46-48) indicate that the Newsletter and Newsflashes are read by over 80% of members and are a key part of being a member of GSNZ. 'Facebook' as a means of social media expression and interaction is the least used means of communication for this Society. Does this reflect the 'greying' of Society members and a desire to leave the IT at work or just a communication method that this Society's members don't engage in for work related issues?

Enjoy issue 28, and as editor/compiler it is always great to read, fix up, and rearrange. I look forward to a bumper issue for November and the necessity to select something to leave out because of a lack of space. If you would like back copies of any issues from the last eight years I am happy to post them on to you.

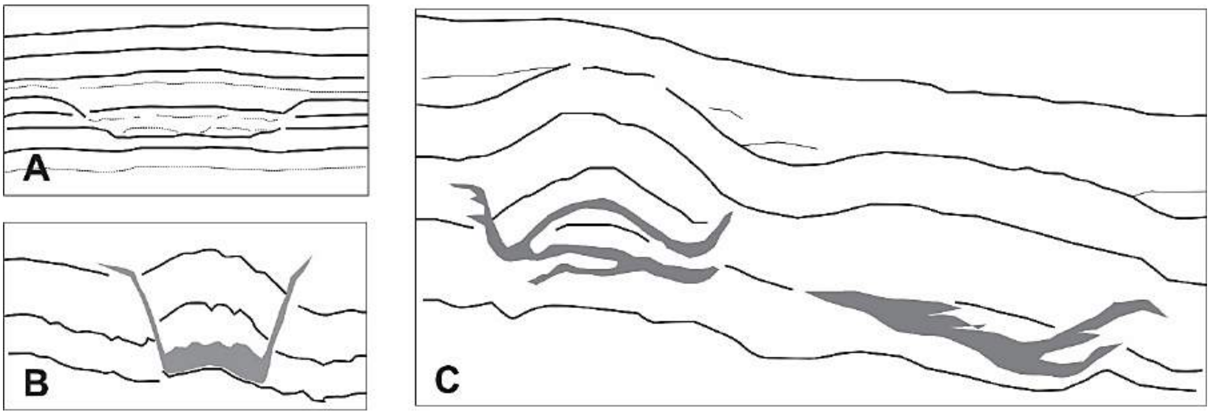
*"It is the imaginative interpretation of a problem which leads to discovery".* R S Allan.

## Saucer sills and sand injectites

Chris Uruski uruskic@gmail.com

During the decades that I've spent interpreting seismic data, particularly from around New Zealand, a number of questions occurred to me that I've not had the time to pursue. Perhaps someone else could use the basic ideas as a research project.

One set of features I've noted are apparent channel-like structures that mound overlying sediments (figure 1). While most of the regional seismic data available is two dimensional (2D), closely-spaced grids show that they are not actually channels as their levels vary from line to line and they may not be continuous. This becomes particularly apparent in 3D data sets (e.g. Blanke, 3013). Typically, the saucer features have a high-amplitude seismic signature that defines a flattish central body flanked by outwards and upwards extending "wings". Saucer structures may be a little as a kilometre or less and up to five or six kilometres across. The commonly-accepted interpretation for many of these features is that they are saucer-shaped igneous sills (e.g. Hansen and Cartwright, 2009; Schofield et al., 2012; Hamilton and Minshell, 2019).




Seismic cross-sections across "channel-like" features at the same scale. A: A well-behaved channel offshore Southern Taranaki B: Sand injectites from the Balder Field, North Sea C: Saucer sills from Deepwater Taranaki.

Sill injections take a variety of forms. Large volumes of magma may be injected along bedding planes to create thick sills such as the well-known Pallisades in New York State, the Whin Sill of northern England and the Ferrar Dolerites of Antarctica. Smaller volumes create smaller structures and the smallest discerned on seismic data are the saucer sills described above.

Saucer sill injections are common in many of New Zealand's offshore basins, particularly in deep water where they appear to be most numerous in water depths greater than 1,000 metres. Presumably, the water depth is not significant in itself, but is controlled to a great extent by crustal structure, which also plays a part in determining sediment thickness. Shallower regions are either buried by the Neogene outgrowth of the shelf, such as in Taranaki, or have relatively thin sediment cover, such as the flank of the Challenger Plateau. In the latter case, magmas able to pass through the thicker crust were commonly extruded to the surface, perhaps as they have less distance to travel through sedimentary rocks. Research on the evolution of saucer sills has concentrated on the mechanical aspects of sill injections proceeding along a series of fractures along bedding planes, finding a vertical weakness and moving up to the next level and so on until the magma source is depleted. While this provides a satisfactory explanation of the formation of saucer sills, particularly as images in relatively low-resolution seismic data, it may not be the entire story.

Sand injectites can produce very similar structures to saucer sills (e.g. Braccini et al., 2008). So how can we tell the difference on seismic data? The physical properties of the rocks involved should provide a clue as igneous sills are hard, crystalline bodies while mobilised sandstone injectites are not, so seismic velocities should give an indication as to composition. Or is it really that simple? The 1975 Canterbury Basin well Resolution-1 sampled the only saucer sill to be drilled in New Zealand to date. The structure appears to be a typical, if complex saucer sill with an overlying mound that is expressed in sedimentary rocks up to Middle Miocene age. A Miocene mounded body is present on the flank of the dome and is likely to have been extruded during the same igneous event as the sills. Radiometric dating (Adams, 1975) gave an absolute age of 12 My and petrological work identified the sill as essentially a basic igneous rock, teschenite (Challis, 1975).

The Cretaceous succession above the sill is about 430 metres thick, dated as entirely Haumurian and dominated by sandstones containing “fragments of volcanic rock and is highly porous” (Milne, 1975). How did the fragments of volcanic rock become incorporated in the sandstones? One possible answer is that the volcanic rock must have been in existence upstream of the sediment flow during the Haumurian. But what if the volcanic fragments were derived from the sill, injected about 40 My after deposition of the sandstone? How could the porosity of the sandstones have been preserved? Zeolites were present in sandstones immediately overlying the sill indicating that contact metasomatism had occurred (Challis, 1975). A sidewall core from 1877.5 metres of black, partially biogenic siltstone carried a 1.5 mm vein of dolomitic carbonate and a second core from 1908.5 metres was of unindurated quartzose siltstone containing abundant radiating aggregates of zeolite. Challis (1975) deduced that contact effects extend at least 34 metres from the intrusion. However, considering the carbonate vein more than 80 metres above the sill, the effects may have extended much further. Metasomatism implies that material has been carried from a source, in this case the sill, suggesting that the igneous fragments might have come from the sill via a series of fractures.

Would the fractures have been caused directly by injection of the sill? Perhaps they were, but what if the Cretaceous sandstone remained poorly lithified when the sill was injected? By the end of the Early Miocene less than 600 metres of sedimentary rocks had been deposited on top of the Cretaceous, so compaction would have been negligible. The Cretaceous sandstones would have retained much of their original porosity and those pores would have been water-filled in all probability. The effect of injecting a 50 metres thick layer of molten magma into such wet sedimentary rocks would be interesting. Temperatures of magma range widely about 1,000ºC, so I imagine that the water in the rocks would be immediately vapourised accompanied by a large increase in volume and substantial fracturing of the rocks. Escaping vapour could have entrained fractured igneous particles and scattered them through the host rock. Furthermore, the host sandstone could also have been entrained to create sand injectites. Could the Miocene mounds actually be sand volcanoes that emanated from hydrothermal vents (Planke et al, 2005)?

The Resolution sill appears to have been injected into the interface between Cretaceous sediments and underlying Torlesse basement, so its base is constrained by the top surface of the basement. In other cases, where sills are injected into wet sedimentary layers, both the top of the sill and its base would pass heat into surrounding sedimentary rocks resulting in large volumes of super-heated steam. Sandstones above the sill might be expected to bulge creating a dome in overlying sediments. Sandstone below the sill would tend to move laterally and its steam-powered buoyancy would start it moving upwards creating a void into which the probably still plastic sill could sag. The two effects acting in concert might explain some of the features observed on seismic data.

Although there has already been some excellent work done on saucer sills around New Zealand, particularly Bischoff et al. (2017) there is more to be done. This note proposes that a third saucer structure may be common in the subsurface in addition to saucer sills and sand injectites; namely a composite of igneous sill and sedimentary injectite. Some large oil fields are associated with sand injectites (e.g. Alba in the North Sea; Newton and Flanagan, 1993; Moore, 2014) and a large dome structure with excellent porosity is what petroleum geologists dream of. Understanding the geology of these structures will become desirable, particularly when the impetus to explore for oil and gas returns to New Zealand, as surely it must if we need to continue using petroleum for the foreseeable future. And we do.

Is this enough to launch a research project? I hope so, although it could all fall at the first hurdle if the igneous fragments in the Cretaceous sandstones of Resolution-1 prove to be unrelated to the sill itself. Nevertheless, there is still a lot that is unknown about the relationships between saucer sills, hydrothermal activity and sand injectites.

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(image from www.niwa.co.nz)

## The Campaign to Save Crater Hill Continues

Bruce W Hayward

Crater Hill (Figs 1, 2) is the last mostly intact, undeveloped volcano in the Auckland Volcanic Field that is privately owned. The Geoscience Society of NZ, and before that the Geological Society of NZ, has been lobbying for its protection for many decades. Crater Hill first appeared in planning documents in 1988 when it was listed in the Auckland Regional Planning Scheme as a place of scientific and natural beauty to be preserved. GSNZ submissions resulted in having Crater Hill included as a scheduled Outstanding Natural Feature (ONF) in the advertised Manukau District Scheme in 1995 and thereafter. GSNZ assisted in defending that scheduling in 1996 and again in 2001.

The campaign took a more urgent turn in 2016 when the Independent Hearings Panel (IHP) on the new Auckland Unitary Plan sided with the owners to have Auckland's Rural Urban Boundary (RUB) moved so that Crater Hill was inside the urban zone. This would have made it far easier for their proposed subdivision to provide land for 550 dwellings to proceed. This IHP recommendation resulted in a pop-up campaign and petition, supported by many GSNZ members, which lobbied Auckland City Councillors. GSNZ President Adrian Pittari put out a press release "condemning the proposed housing on a potential world heritage volcano". The Council deliberated and rejected the IHP's recommendation by a majority of one vote, to move the RUB (in the Auckland Unitary Plan) to beyond Crater Hill and nearby Pukaki Lagoon explosion crater.

Crater Hill's owners appealed this decision to the Environment Court and the decision was defended by Auckland Council and the Auckland Volcanic Cones Protection Society. GSNZ decided that it could not become involved formally as there was a slight chance that costs might be awarded against the society should the case be lost. GSNZ did resolve however to support the Volcanic Cones Society in the campaign and Bruce Hayward provided expert evidence on their behalf. Mediation meetings between the parties in 2017 not surprisingly found no common ground and the case went to the Environment Court hearing later that year. After many months of deliberation, the court found definitively in favour of the defendant (Auckland Council) on both Pukaki Lagoon and Crater Hill.

The owners next appealed to the High Court and this was heard by a High Court judge late last year with his interim decision being released in March 2019 subject to still further submissions from both sides to be heard in September. Once again, the court has signaled that it agrees that Crater Hill is an Outstanding Natural Feature and is not suitable for the high-density subdivision that was being proposed and therefore should lie outside the RUB. This legal battle has been the Volcanic Cone Society's largest and it has exhausted all its financial resources on it with their dedicated barrister doing much work pro bono. Our society made a donation towards the cause along with many members of the Volcanic Cones Society.

**Why Crater Hill is considered to be of National Significance**

Crater Hill Volcano, its two lava caves (e.g. Kermode, 1994; Crossley, 2006) and quarry exposures of the tuff and scoria sequence (e.g. Houghton et al., 1991, 1999) were individually assessed as being of national significance when first entered in GSNZ's Geopreservation Inventory in 1992 (Kermode et al., 1992). Unfortunately, the quarry exposures have been buried by clean fill during permitted quarry rehabilitation in the last two decades (in spite of their being scheduled in the Manukau District Scheme as part of the ONF) and they are no longer in the Inventory.

Crater Hill Volcano consists of a maar crater surrounded by an unbreached tuff ring (Fig. 1). Young (Late Quaternary) basaltic maar craters like this, with their landforms still little modified by erosion, occur in three places in New Zealand: the Auckland Volcanic Field, Ohakune-Rotokura (south of Ruapehu) and Rotokawau (Rotorua). There are four craters at each of the latter two localities, whereas Auckland has at least 18 that still retain their near circular crater shape and surrounding tuff ring.

Crater Hill's ranking of national importance is derived from the combination of:

1. Its tuff ring (both inner and outer slopes) being the least modified in the Auckland Field (Fig. 1).

Fig. 1. Crater Hill Volcano maar crater and tuff ring from the southwest, 2009.

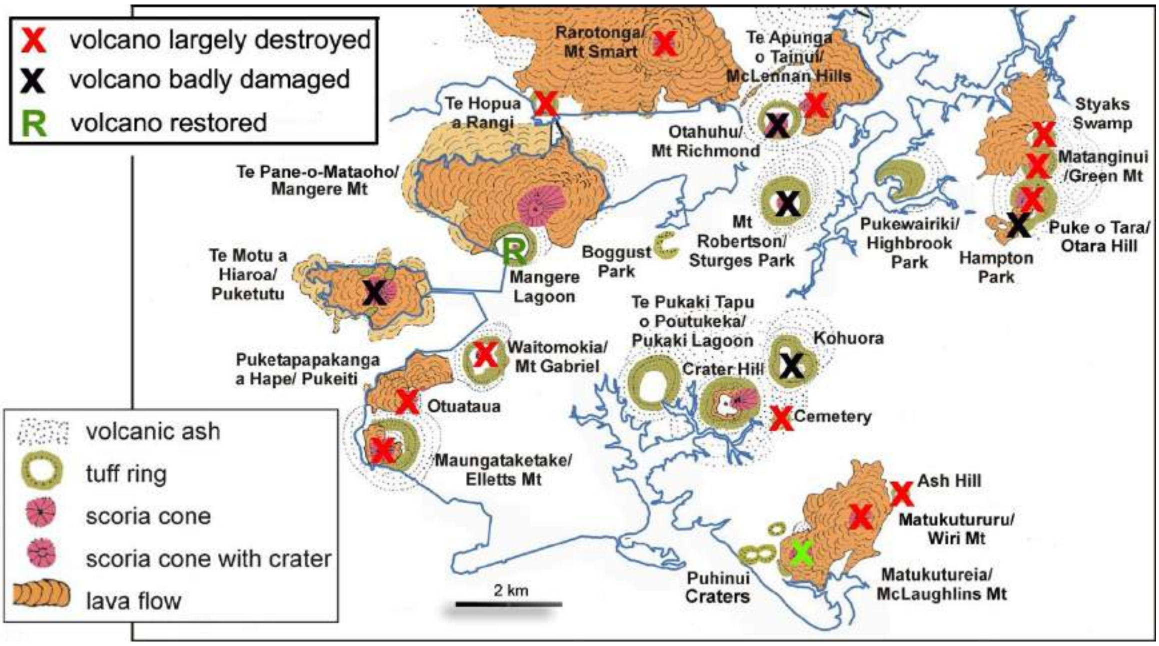


Fig. 2. Crater Hill Volcano is in the southern half of the Auckland Volcanic Field where far more of the volcanoes have been severely damaged by quarrying and subdivision.

2. Its excellently-preserved scalloped crater rim, produced by numerous syn-eruption slump scarps (Fig. 3).

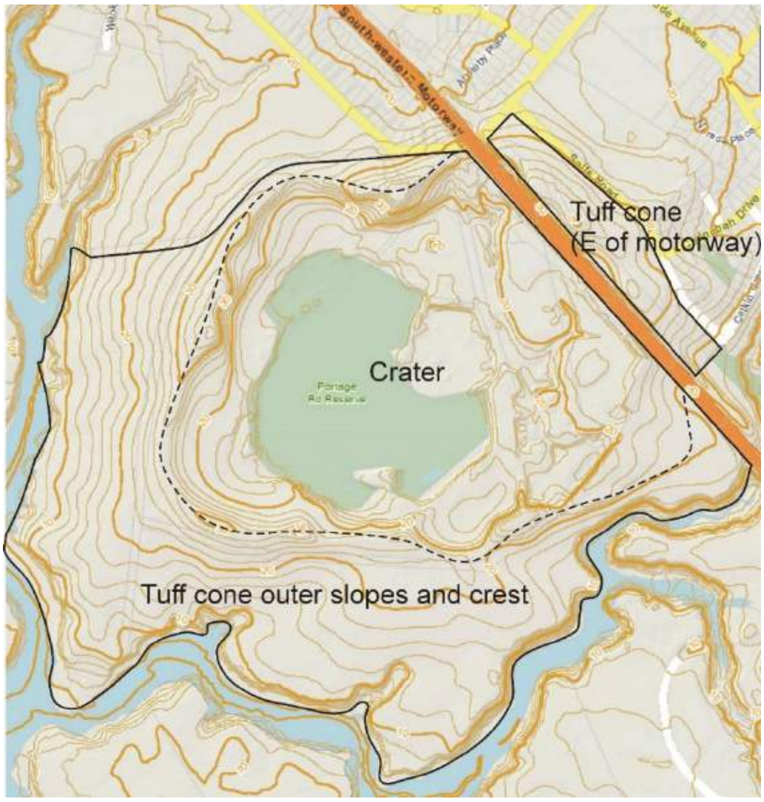


Fig. 3. Contour map of Crater Hill showing the scalloped crest of the tuff ring produced by slump scarps and location of the southwest Motorway and quarried area.

3. One of only two maar craters in Auckland still retaining its original freshwater lake (Fig. 4).

Fig. 4. View from the western crest of the tuff ring over the crater and its freshwater lake and island.

4. Best preserved of only four NZ maar craters containing evidence of a lava lake having partly filled the crater (the others are Three Kings, Auckland Domain, and Grafton).

5. Presence of a line of congealed basalt lava inside the crater, marking the upper level of the lava lake before it withdrew back down the vent (Fig. 5).

Fig. 5. The entrance to Selfs Lava Cave is in the bushes (right centre). It was formed under the surface crust of the lava lake as the molten lava was sucked back down the volcano's throat.

6. Presence of a heap of basalt slabs forming an island above the main vent. This is inferred to be solidified portions of the crust that formed on the lava lake surface, that were not sucked back down the vent as the lava lake drained (Fig. 4).

7. The only NZ examples of lava caves (Selfs and Underground Press) formed beneath the solidified surface crust of a lava lake (Fig. 5).

**Crater Hill is not pristine**

Like all the volcanoes in Auckland (except Motukorea), Crater Hill has not been immune from damage by quarrying and other activities related to a growing Auckland City. The reason why the quarry exposures were considered significant was that they recorded interspersed episodes of wet tuff and dry scoria eruptions from several vents during the construction of the tuff ring. The presence of these scoria layers in the eastern side of the tuff ring resulted in their being quarried over many decades, starting about 1960. In this century the quarried-out area has been used for clean fill and the approximate original shape of this part of the tuff ring has now been restored. Alongside the quarried part of the tuff ring there used to be a small scoria cone which was quarried away between 1889 and 1950 (Fig. 6). Its flat circular stump abuts the eastern side of the crater lake. Total quarried area was ~150,000 sq. m.

The other major damage to Crater Hill Volcano has been the construction in the 1980s of Auckland's Southwest Motorway through the eastern part of the tuff ring (~30,000 sq. m) adjacent to the quarry zone. This cut off the highest part of the tuff ring crest (in the east) from the rest of the volcano. The present battle is to preserve the 80-85% of the volcano that lies to the west of the motorway and includes the restored quarry zone and unrestored stump of the scoria cone (~1,100,000 sq. m).

**Housing subdivision proposal**

During the IHP hearings the owners introduced their subdivision proposals for high density housing in three areas. Two housing area covered a significant proportion of the intact outer western and southern slopes of the tuff ring that slope down to the mangrove-lined shore of an arm of the Manukau Harbour. The third area covered all the area that had been quarried inside the eastern part of the tuff ring and the stump of the scoria cone extending down to the edge of the central crater lake (Fig. 7). Auckland Council and the Volcanic Cones Society are of the opinion that neither subdivision would result in acceptable minimal damage to the aesthetic values of the volcano. Scientifically it can be argued that the quarried areas no longer retain any visible original features. A large clump of multi-storey houses extending right down to the lake edge inside the crater will certainly have a major impact on the natural aesthetic appeal of the crater. To be fair it should be noted that in their subdivision plans the owners proposed that mosthe unquarried and undamaged parts of the crater (about 70% of it) would be set aside as a private reserve (to protect the pre-European archaeology).

**The future?**

At this point the Volcanic Cones Society and Auckland Council have been successful in protecting Crater Hill but the owners are weighing up their options in terms of further appeals to the Court of Appeal and this will depend on the final decision from the High Court. Even if all appeals are unsuccessful, the win is unlikely to hold forever. The pressure of development in this part of Auckland will be too great. The only really viable position for Crater Hill is public ownership. This will need a well-orchestrated campaign at both regional and national level and will likely cost tens of millions of dollars. It will require much drive and determination and undoubtedly our Society will have to play its part if Crater Hill is to be saved for future generations to appreciate and enjoy (Fig. 8).

Fig. 6. Crater Hill in 1958, soon after the small scoria cone had been quarried away but earthworks for the tuff ring quarry and southwestern motorway had not started. Photo: Whites Aviation.

Fig. 7. View from the southeast over Crater Hill with the areas proposed for housing subdivision outlined in red. The quarried area is within the right-hand polygon. 2009.

Fig. 8. Crater Hill Volcano can be seen out the window of all airplanes taking off or landing from the east at Auckland International Airport, 2008.

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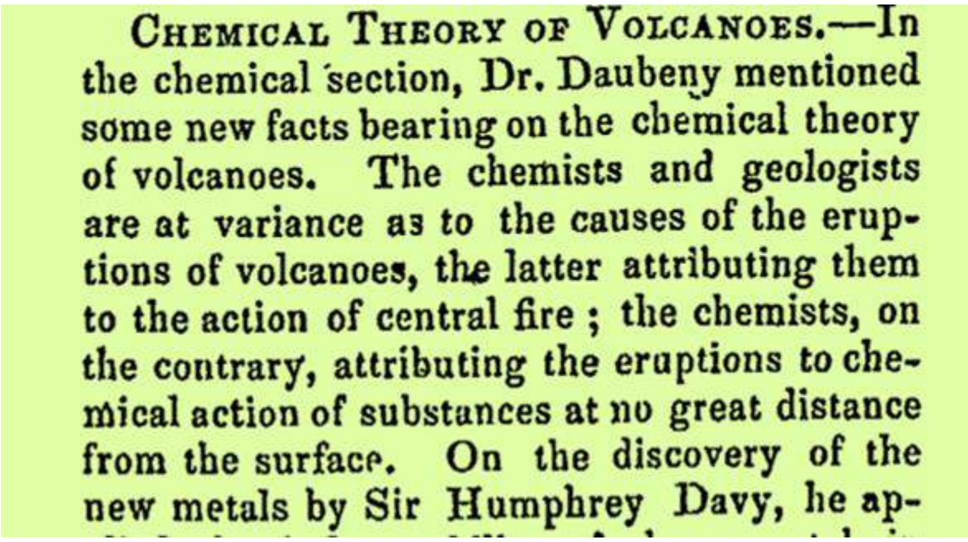

CHEMICAL THEORY OF VOLCANOES.—In the chemical section, Dr. Daubeny mentioned some new facts bearing on the chemical theory of volcanoes. The chemists and geologists are at variance as to the causes of the eruptions of volcanoes, the latter attributing them to the action of central fire; the chemists, on the contrary, attributing the eruptions to chemical action of substances at no great distance from the surface. On the discovery of the new metals by Sir Humphrey Davy, he ap-

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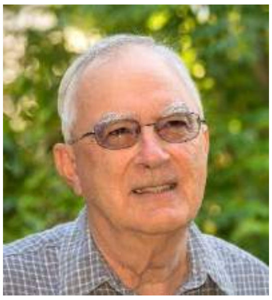

## South Westland Geology – memories and some unresolved problems

Simon Nathan s.nathan@xtra.co.nz

The geology of the narrow strip of rock to the west of the Alpine Fault in South Westland has long fascinated me. I have visited the region many times over the last fifty years, and investigated different aspects of the geology. I often felt surrounded by history as the area was first explored by Charlie 'Explorer' Douglas (Nathan 2017), and was where Harold Wellman first recognised the Alpine Fault (Nathan 2011). Sadly, my fieldwork days are now over, but I would like to record some unresolved geological problems in the hope that a younger generation of geologists may try to resolve them.

### Memories

My first trip to South Westland was as a student, about 1964, while construction of the last section of the Paringa-Haast highway was still underway. My souvenir of the trip is a strange, white spotty metamorphic rock – many years later I recognized that it was a calc-silicate pod, a metamorphosed concretion from the Greenland Group.

When I joined the Geological Survey in 1967, one of my first jobs was to log the fresh rock exposures along the newly completed highway, and I was intrigued by the discovery of an ammonite and *Inoceramus* in late Cretaceous marine beds. About this time the first licences were being issued for exploration of offshore blocks around New Zealand. Several oil exploration companies were interested in the narrow steeply-dipping strip of late Cretaceous and Tertiary rocks exposed along the coast as a guide to what might be found offshore. The initial oil company results were confusing, so the Geological Survey was asked to undertake a stratigraphic survey and synthesis of South Westland. This led to a glorious summer in 1973-74 when I traversed the coastline between Bruce Bay and Milford Sound, a distance of over 200 kilometres, measuring and describing sections and collecting micropaleontological samples. We also visited a very remote oil seep on the coast at Madagascar Beach. It turned out that the stratigraphic succession was rather different to that further north on the West Coast, with a continuous marine sequence from late Cretaceous to Pliocene containing interbedded volcanic rocks at different levels. The results were published in two papers (Nathan 1977, 1978), which laid out a stratigraphic framework, tweaked a little in later years as more information became available (Nathan & others 1986; Sutherland, Nathan & Turnbull 1995; Sutherland & others 1996). Later work on the volcanic rocks clarified their dating and geochemistry (Sewell & Nathan 1987; Phillips & others 2005).

*Figure 1. Campsite at Big Bay, 1973. From left, Rudi Katz, Chris Adams, Simon Nathan, Malcolm Laird. A few hours later a southerly front came through, and we spent a miserable night trying to hold the tents down*]

In 1983-85 the NZ Forest Service undertook a major interdisciplinary survey aimed at assessing the forestry potential of South Westland – one of the last major stands of lowland native forest – and I was in charge of geological investigations. A visiting geologist, Greg Mortimer, mapped the area between Fox Glacier and Mahitahi (Mortimer & others 1984), and the following year I supervised a group of students mapping the area between Mahitahi and Ship Creek. This led to the completion of three MSc theses by David Adams, Mark Aliprantis and Mark Eggers, and the results of this work were eventually incorporated in QMAP Haast. [As an aside, a political decision was made that no more native forest would be logged in South Westland, so the geological work was never used as intended]. However, it did lead to my renewed interest in the geochemistry and metamorphism of the local basement rocks, the Greenland Group, that I had studied further north. Chris Adams and I collected sequences of samples from key localities that were used for geochemistry and isotope dating. The geochemical work confirmed that the Greenland Group is a fairly uniform, quartzose turbidite sequence, but that there was a gradual increase in a volcanogenic component towards the south (Roser & others 1996).

I gradually realised that there was an eastwards increase in the metamorphic grade of Greenland Group, with amphibolite facies rocks exposed immediately adjacent to the Alpine Fault – the mirror image of the isograds in the Haast Schist on the opposite side of the Alpine Fault. I presented this idea at a GSNZ conference in 1987, but was discouraged from publishing it by the negative reactions of some Otago colleagues who felt that I lacked metamorphic expertise. The idea lay dormant for a long time, until I persuaded Nick Mortimer to take a lead role in completing a paper incorporating my ideas and other more recent work (Mortimer and others 2012).

**Some unresolved problems**

*1. Allochthony in South Westland*

In my initial stratigraphic work, I realised that the contact between the late Miocene Tititira Formation and apparently overlying deep-water limestone of the Jackson Formation was invariably tectonised (Nathan 1978, pp 347-48). The late Rudi Katz argued that it probably represented an overthrust, which I was reluctant to accept at the time. Unfortunately, the age of the Jackson Formation was uncertain, but more recent paleontological evidence shows that it is Eocene-Oligocene (Sutherland and others 1996), and thus older than the Tititira Formation. I now have no doubt that there is a major, late Cenozoic overthrust, occurring over a distance of more than 100 kilometres along the exposed length of the contact. This is a major tectonic feature, possibly of the magnitude of the Northland Allochthon, yet it has not been mentioned in any recent syntheses of New Zealand's tectonic history. There are some other stratigraphic curiosities that could be due to tectonic transport. For example, an isolated, fault-bounded, area of Eocene coal measures in Coal Creek seems anomalous in terms of regional paleogeography when a deep-water Eocene sequence occurs nearby. This is aspect of South Westland geology that is long-overdue for re-evaluation.

*2. Hi-Al, low-K basalts*

I mapped three small basic intrusions in the lower reaches of the Hope River, apparently intruding the Tititira and Jackson Formations, although field relations were not clear (Nathan 1978, fig 5 and p 349). The chemical composition of these intrusions is similar - all high-Al and low-K basalts (Nathan 1978, table 4), unlike any other volcanic rocks described from South Westland. I attempted K-Ar dating to determine the age of these rocks, but the very low K content means that there was virtually no radiogenic argon. These intrusions may represent an unrecorded late Cenozoic magmatic episode. The area needs to be re-examined to determine field relationships, and the basalts need to be radiometrically dated.

*3. Pseudotachylite at Big Bay.*

A peculiar chert-like band, about 0.2m thick, occurs at the faulted contact between two parts of the Tititira Formation on the north side of Big Bay. Although mapped as a lamprophyre dike by previous writers, microscopic examination shows that it is made of isotropic brown glass containing tiny quartz fragments. This is described by Nathan (1978, pp 332-333), but as far as I am aware no-one has re-examined this locality. Does anyone know of other localities where pseudotachylite occurs in late Cenozoic sediments? [Incidentally, the lamprophyric rocks at Crayfish Rock and Penguin Rock have never been analysed or dated as far as I know]

4. *Rhyolitic rocks within the Greenland Group*

Most of the Greenland Group is a turbidite succession, but in the catchment of Powers Creek, north of Paringa there are areas of rhyolite/dacite, metamorphosed to biotite grade along with the surrounding metasedimentary rocks. The field relationships of these metavolcanic rocks are unclear – it is not certain if they intrude or are interbedded with the sedimentary rocks. It is possible that they represent a hitherto unrecognized Paleozoic magmatic event, so it is important that they are re-examined in the field, analysed and radiometrically dated.

5. *Provenance of the Greenland Group*

Greenland Group rocks in Collie Creek, near Lake Paringa, contain pebble conglomerates including granite and volcanic pebbles. Microscopic examination of these conglomerates should reveal information on the provenance of this widespread unit.

**Final thoughts**

I am very happy to provide more information on any of the problems and localities mentioned above – please contact me if you would like to discuss further. There are fieldsheets for most areas, and rock specimens are held in the PETLAB database.

Finally, I would like to thank many geological colleagues who have accompanied me on South Westland trips or undertaken specialist investigations of rocks and fossils. As the years pass, memories fade of sandflies and rain, and I mainly recall the good parts of fieldwork, and fascinating geology of South Westland.

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## Geoscience for Kids: Science Education and the Science Teaching Leadership Programme

*Edie Fisher and Adrian Pittari*

Edie Fisher teaches 9 – 11 year olds at Hamilton East Primary School and is a participant teacher on the Royal Society Te Apārangi Science Teaching Leadership Programme (STLP). For the first phase of this programme (i.e. the last 6 months) Edie has been hosted by Adrian Pittari and the volcanology group at the University of Waikato and has become absorbed in the world of geosciences. At the same time, she has been attending professional development in science curriculum and leadership with the Royal Society Te Apārangi. This article discusses the current position of science education in New Zealand schools, introduces the STLP, and outlines some of the geoscience activities she has been involved with at the University, including some findings of her own mini-project – the ‘Geology of Hamilton East Primary School’.

## What is the Science Teaching Leadership Programme?

In New Zealand schools many students are losing interest in science as a subject to study and by high school see no relevance to it in their lives, in fact for some, its only purpose is for passing examinations (Harlen, 2010). One reason for this is the way it is taught, as a set of disconnected facts to be memorised (Harlen, 2014). Teachers' own lack of confidence in teaching science, especially in primary schools (Gluckman, 2011) and a focus on science education only being relevant to those pursuing a career in science contribute to the problem. It is now widely acknowledged that a level of scientific literacy is vital for all students to be able to make informed decisions about global issues facing them, not only those following science as a career. Young people need an understanding of relevant scientific ideas in order to critically navigate their way through the endless pseudoscience and misinformation they are faced with.

Teacher training programmes in New Zealand provide less pre-service science education for trainee teachers compared to many others in the OECD and receive less ongoing science professional development (Chamberlain and Caygill, 2012). In 2010 the Science Advisory Services for teachers were withdrawn (Thrupp, 2010) and have not been reinstated, leaving teachers with no support or guidance for teaching science. So how does a teacher provide quality, relevant, engaging science teaching in an already crowded curriculum where literacy and numeracy hold top priority, and what is the future for science education in primary, intermediate and secondary schools?

The NZ curriculum (MOE, 2007) states 'The Nature of Science strand is the overarching unifying strand' of the science learning area. The 'Nature of Science' is the key to teaching science from year 0 to year 10; our students need to understand what science actually is and how scientists work. They must develop the skills of scientific capabilities to be able to think scientifically and connect the big ideas in science to their own world. Memorising content knowledge to regurgitate in a test provides little scientific understanding or skill, yet this is often exactly how science is taught, the result is a significant number of students disengaging from science.

The Science Teaching Leadership Programme (STLP) run by the Royal Society Te Apārangi is a professional development programme for NZ teachers of students in years 1 – 10, funded by the Ministry of Business, Innovation and Employment. The objective is to enhance science teaching within school communities by nominating teachers who spend two school terms working alongside scientists to gain a deeper understanding of the Nature of Science, and undertaking leadership training. On their return to school, the teachers work with students, staff and their local community to enhance the quality of science teaching and learning in their school. This includes building partnerships with science organisations and developing robust and sustainable science programmes in the school.

This year Edie has been working with Adrian Pittari and his PhD and Masters students in their research. She has experienced many parts of the research process from identifying volcanic areas of interest, attending field research activities, processing samples, observing samples under the microscope and SEM, visiting the electron microprobe, laser sizer work, and discussing results. Not your usual day at the office for a primary school teacher! Working day to day with scientists has given Edie a more realistic understanding of the reality of science as a career, what scientists do and the importance of and impact science has in our lives. She combines her experiences with that of nine other participant teachers working across New Zealand in different scientific fields. These teachers will return to school to share their experiences and lead their colleagues to improve the quality of science teaching and raise the scientific literacy of their students.

**Geology of Hamilton East Primary School**

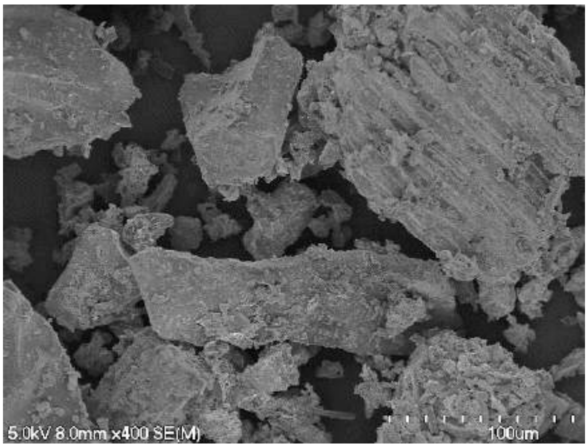
Edie is building on her experience by undertaking her own small research project on the Geology of Hamilton East Primary School. Here are a few highlights and results of this project.

Hamilton East Primary School was built in 1872 and is situated centrally in the Hamilton basin approximately 300 metres east of the Waikato River. It covers three levels of land with the lowest field (Putikitiki) sitting above Seeley Gully, water from the gully is piped down to the river under the field. The hill slope on the south side of Seeley Gully, which forms the playing field, was studied and soft outcrop was found (Fig.1). The deposits are mostly Pleistocene volcaniclastic alluvial sediments of the Hinuera Formation and underlying Walton Subgroup which also includes primary ignimbrites and other tephras.

Four sites positioned at different heights on the southern hillslope were described in the field and sampled to observe in thin section under the petrographic microscope, for grainsize distribution by a laser diffraction particle size analyser, and further observation by a scanning electron microscope. The complete results of the project are not reported in detail here. However, the lowermost ignimbrite is described to illustrate the evidence for volcanic products beneath the school, and thus allude to the presence of ideal natural materials on site that can be used for teaching in the classroom and the school grounds.

At the lowermost site there was an outcrop of soft white ash with pumice lapilli and a few rhyolite lithics that had the appearance of a primary ignimbrite. The deposit comprised crystals of quartz, plagioclase, augite, hypersthene, hornblende and opaque iron oxides, and a matrix of glass shards, with a median grainsize of 48 µm, but ranging up to 100 - 200 µm (Fig. 2a). A minor component of the ignimbrite included intact diatoms, typically 25 µm in size (Fig. 2b).


Figure 1. The southern hillslope of Seeley Gully which was examined and sampled for further geological analysis.

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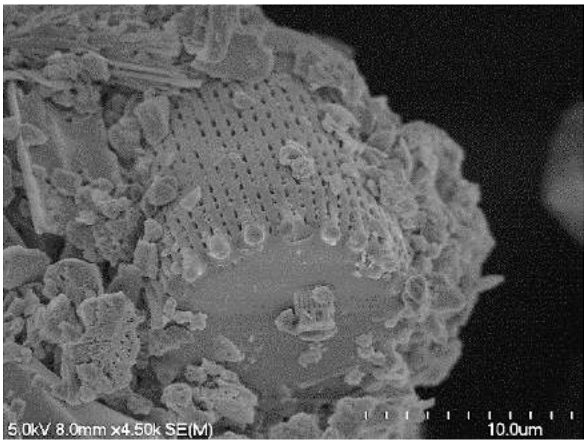


b

Figure 2. (a) Typical glass and pumice shards, and (b) an intact diatom, found within the lower ignimbrite deposit.

## Using geoscience in the classroom

Students learn best and engage most when learning experiences are authentic and relevant to their lives (MOE, 2007). Edie intends to use this research data to develop a teaching unit about the volcanology and geology that is literally beneath her students' feet. She will draw on her experiences by teaching the students how to carry out their own geological research project, they will look for outcrops and make focussed observations, collect samples and look at microscope work. Her students will develop their scientific capabilities by engaging in an authentic, relevant scientific process.

Edie is inspired by the links she sees between geoscience and other curriculum areas. She can teach her students maths through measuring deposits, art through looking at volcanic landscapes or observing minerals under microscopes and literacy by creating reports or stories about the outcomes of their geological research.

Science provides contexts for rich and engaging learning experiences across the curriculum and the STLP is a valuable programme supporting New Zealand teachers to improve science education for all young people to become future scientifically literate citizens.

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## An enigmatic concretion resembling a giant puzzling palm-like fruit from Northland

Seabourne Rust, Daphne Lee, John Conran, Bruce Hayward

In 2017, Northland resident Ginny Smith collected an unusual rock the size and shape of a rugby ball (Fig. 1) while fossicking on the shores of the Kaipara Harbour. The relatively heavy, spindle-shape geological curiosity measures about 34 cm in length, is longitudinally grooved, and appears to resemble some kind of giant fossilised 'seed'.

Ginny sent photographs of the specimen to various palaeontologists to see if anyone could identify it. Some were unsure if it was indeed organic – Bruce Hayward suggested it was probably an unusual type of concretion. However, the consensus from several paleobotanists (overseas) who looked at the pictures is that it might be a fossil fruit, one of the largest ever discovered. Could this be the world's largest fossil fruit?

Their tentative identification as a fruit hinged on several points:

Firstly, regarding the specimens' fusiform shape, symmetry and longitudinal surface texture:

1. It is largely symmetrical, but with the remnants of a pointed, style-like structure at the apex and a possible basal attachment scar at the other.
2. Secondly, traces of what appear to have been a skin-like outer wall are preserved as a blackish, carbonised layer? overlying a wrinkled, almond-shaped inner kernel.

However, they were left puzzled by some key questions:

1. How old is it?
2. What formation did it come from?
3. What kind of fruit could this represent?

Certainly the size of the specimen precludes most known fruits and seeds. Upon closer inspection it is not entirely symmetrical. Although superficially resembling the husk-covered fruit of a mangrove palm (Nypa) or coconut, the outer 'layers' are thin and lack the thick buoyant fibrous layer of these water dispersed palms. There are no germination pore-like features.

There are two possible contenders with fruit that might approach this size and shape: the first is an extinct palm, as there are no close matches in the modern Arecaceae; the other is the flowering plant family Lecythidaceae that includes Brazil nuts and the mangrove *Barringtonia,* as both of these families include large fruited, water-dispersed species with a hard, seed-like inner fruit layer. However if it is a fruit, it is most likely to have been gravity- and/or water-dispersed (there is no evidence that any dinosaurs or moa could have swallowed and passed a fruit of this size!). It would have been cemented very rapidly shortly after dropping from the parent tree and dispersal, as it is uncompressed.

Could it actually represent the fossil remains of a very large palm-like seed, or alternatively, could it also be of completely inorganic origin, that is a case of a concretion mimicking biology? We need to return to the important first two questions regarding provenance.

Ginny found the specimen loose and isolated on the shore of the Kaipara Harbour, so it might have been sourced from nearby terrestrial Miocene strata of the Puketi Formation at Tinopai (Jones 1972). If so, SR offered yet another additional suggestion to consider, could this be a cast of a nikau palm leaf sheath from the base of a large frond? Fallen fronds are tough and durable; the bowl-like bases can hold water. Perhaps one of these was filled with volcaniclastic sediment from the nearby Miocene Kaipara ignimbrite volcanoes (see Hayward 2017), or washed into a muddy pond or waterway and ended up buried in a marginal marine setting. Certainly, palm fossils, identified as species of *Rhapalostylis* (nīkau)*,* *Cocos* (coconuts) and *Phoenicites* (formerly *Seaforthia*) are known from including *Rhapalostylis* and *Seaforthia* spp. are known from Miocene sediments of Northland, including the Tinopai-Hukatere area (leaves and pollen). If a palm sheath were filled with sediment from above, the top surface would be flatter than the convex cast base and the base should also have impression of the frond bowl surface, including fine ribbing from the parallel veination. However, in Ginny's specimen the ridges are somewhat broader and more irregular than for palm sheaths and, notably, there are some that curve across the surface transversely. Thus, while this theory certainly stimulated some discussion, upon consideration, it seemed unlikely!

In January 2019 one of us (SR) was finally able to meet up with Ginny and examine her find, and, after seeing the actual specimen, became less convinced of a plant origin.

Upon further discussion, Ginny recalled it as being found in the Bull Point area, which is known for Cretaceous concretions (see Hayward 2017, Hodgson 1968), some of which contain ammonites around 80 million years old. Closer inspection revealed the unusual rock to be a cemented mass of marine-deposited muddy sandstone, for it contains tiny shell fragments. The sediment is micaceous and there appears to be some minor carbonaceous material. It also exhibits the remains of a thin, dark surface layer that was once smooth; rather than carbon, this may be iron oxide. As initially noted by Bruce Hayward, the high density and heavy weight (approx 4 kg) of the specimen is consistent with barite or siderite mineralization; a feature shared with other concretions from the Punakitere Sandstone at Bull Point. The pointed end of this specimen is unusual, as are the surface pattern of ridges; not something typically observed in most concretions, but these could also be a weathering feature. BH also suggested the apparent ribs on the outside and partly reticulate on the other side may be due to septarian shrinkage at one stage. We know concretions do form in a wide variety of shapes and textures (e.g. Rust 2014) and many can resemble biological forms, so whatever the overall appearance, this source seems to have the strongest probability.

To summarise, despite being a little uncertain of its origin, if it is indeed sourced from Bull Point marine-deposited strata and Cretaceous in age, in our opinion Ginny's find is highly likely to be an unusual concretion. Nevertheless, if simply a concretion, its resemblance to a common biological shape (especially for palms) is uncanny! Human nature often leads us at first glance to see recognizable forms, hence we must be cautious – as the saying goes: “if it looks “too good to be true”, it probably is”. Further research and wider opinion is of course welcomed, although we are not ready to section the specimen just yet to see what is inside! We are grateful that Ginny has brought it to the attention of the geological community. Her find is incredibly enigmatic, and regardless of origin, is an unusual and fascinating curiosity.

Images of the concretion in question.

Ginny Smith
with her concretion

Concretion (right) next to a Nikau Palm sheath

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**GEOSCIENCE QUIZ 27**
by Aenigmatite

**Eponyms**

1. After whom are Barrovian zones (medium-pressure metamorphic rock series) named?
2. Would you find most Bouma sequences in clastic, carbonate or evaporite sedimentary rocks?
3. Which two New Zealand petrologists have minerals named after them?
4. What feature is named after Lamont Doherty geoscientist and cartographer Marie Tharp?
5. New Zealand's Stokes Magnetic Anomaly. Who was Stokes?
6. What does the Wilson cycle explain?

**Quiz answers**

1. English geologist George Barrow (1853-1932). 2. Clastic (named after Dutch sedimentologist Arnold Bouma). 3. Colin Hutton (huttonite $ThSiO_4$, a radioactive orthosilicate) and Doug Coombs (coombsite $K(Mn,Fe,Mg)_{13}(Si,Al)_{18}O_{42}(OH)_{14}$, a manganese layer silicate). 4. The Tharp Fracture Zone which cuts the Pacific-Antarctic ridge. 5. John Lort Stokes, RN who commanded HMS Acheron during the hydrographic surveys of the New Zealand coast in the 1840s-50s, and who discovered magnetic declination anomalies near Nelson. 6. The opening of an ocean basin between continents followed by convergence, ocean basin closure and continent-continent-collision (named after Canadian geophysicist Tuzo Wilson).

**And of course, from NCEA Level 2, 2018 (as91191)**
(Demonstrate understanding of the causes of extreme Earth events in NZ)
https://www.nzqa.govt.nz/nqfdocs/ncea-resource/achievements/2015/as91191.pdf

QUESTION THREE: DOUBTFUL SOUND, FIORDLAND – LANDSLIDES AND TSUNAMIS

**Explain in detail** how large summit-to-valley-floor landslides in this area (https://teara.govt.nz/en/photograph/6209/landslide-fiordland) produced localised tsunami waves, sometimes of large amplitude of up to 5 metres.
In your answer, you should:
• annotate the diagram below to describe how large landslides into a fiord can produce large amplitude tsunamis. (Diagram not reproduced).
• explain how the amount of material displaced by the landslide affects the amount of water displaced.
• explain how the height and width of the fiord affects the amplitude of the tsunami.

### Young Researcher Travel Grant (YRTG)

We have just approved funds for the June round under altered rules:

“Applications will be considered on merit in a maximum of two rounds during the course of the year. Applications are due**September 1st**. After the June round, the grant pool is not recharged until the following year and therefore the September round will proceed at the GSNZ committee’s discretion “.

……………………………………………………………………………..

### CONGRATULATIONS To Donna-Eberhart Phillips

Prof. Martha Savage      Victoria University of Wellington

**Donna was Elected Fellow of the American Geophysical Union December 2018**

Her citation was: For fundamental contributions to the seismotectonic analysis of subduction zones and fault zones and innovations in seismic tomography.

## EXCURSIONS TO THE CHATHAMS AND NEW CALEDONIA

Hamish Campbell and Chris Adams are still leading regular annual excursions to eastern-most Zealandia (Chatham Islands), and also to northern-most Zealandia (New Caledonia). Needless to say, they have a geological focus but in reality, they are 6-day (Chathams) or 10-day (New Caledonia) 'conversations' with like-minded explorers. Fine company, cuisine and adventure guaranteed.

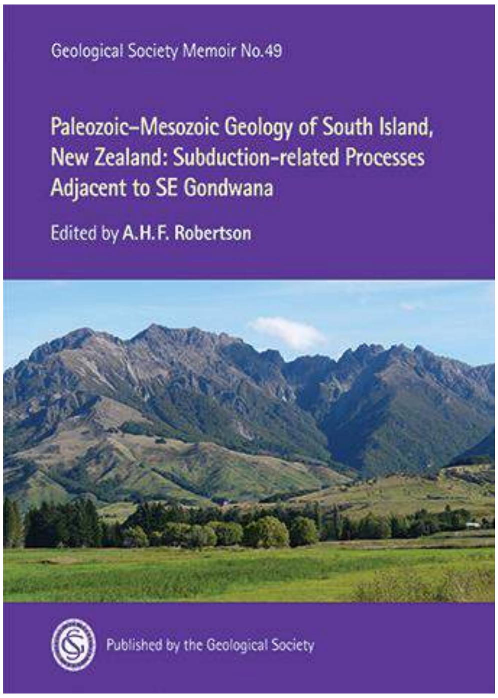
Next trips to the Chatham Islands:
Trip 1: Wednesday 4 to Monday 9 September and
Trip 2: Wednesday 11 to Monday 16 September 2019.

**Next trip to New Caledonia: 22-31 March 2020**
If interested, please get in touch at:
Hamish.Campbell19@outlook.com
Hamish Campbell & Chris Adams

## Announcing a substantive new contribution to our understanding of New Zealand's basement geology

Hamish Campbell & Nick Mortimer

**"Paleozoic-Mesozoic Geology of South Island, New Zealand; Subduction-related Processes Adjacent to SE Gondwana"**




*Geological Society Memoir 49*
Edited by A.H.F. Robertson

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This *GSL Memoir* presents a set of papers that provide new data and interpretations of the Permian–Triassic Brook Street, Murihiku and Dun Mountain-Maitai terranes of the South Island, New Zealand.

Author/editor Alistair Robertson in his office at the Grant Institute, University of Edinburgh (Kings Gardens). Image: Hamish Campbell (Feb.28, 2019)

Following an introduction, an account of previous work, and a review of Permian-Triassic biostratigraphy (Chap 1-3), there are eleven individual papers (Chap 4-14) that focus primarily on the Permian magmatic arc of the Brook Street Terrane, the classic Permian Dun Mountain Ophiolite and the Permian–Triassic Maitai Group sedimentary sequence.
The new results are largely geochemical and are dominantly the work of University of Edinburgh geoscientists Alastair Robertson and Romesh Palamakumbura. The results emphasize the role of subduction and terrane displacement adjacent to the Permo-Triassic Gondwana margin, and present insights into subduction initiation, supra-subduction zone oceanic crust genesis and forearc basin evolution. The 15 chapters build on and advance the classic work done by people like Doug Coombs, Chuck Landis and Barry Roser.

The 20 contributing authors are: CJ Adams, HJ Campbell, V Chatzaras, S Donnelly, L German, WL Griffin, MR Johnston, D Jugum, SC Kruckenberg, WM Lamb, B Miller, RJ Morris, N Mortimer, J Newman, R Palamakumbura, JM Palin, AHF Robertson, E Stewart, B Tikoff and RE Turnbull.

The memoir concludes with a wide-ranging summary and synthesis (Chap 15) of the regional Cambrian to Early Cretaceous tectonostratigraphy of New Zealand's South Island in relation to the wider areas of Zealandia, East Australia and West Antarctica.

This contribution offers a fresh and up-to-date perspective on some of New Zealand's iconic basement rocks and will interest stratigraphers, sedimentologists, palaeontologists, igneous petrologists, geochemists, geochronologists and economic geologists. It is aimed at professional geologists and advanced students of geology.

Productus Creek Group; on Beaumont Station, Wairaki Hills, Southland: Gillian & Alastair Robertson, and Hamish Campbell; searching for tuffs in Glendale Limestone.

**S J Hastie Sholarship Award Report**

**Sydney "Sid" Hastie (1908-1996)**
Sydney J. Hastie, who was well into his eighties when he died in 1996, was a major benefactor of the Society. He donated a substantial sum of money in 1994, which was the basis for the S.J. Hastie Scholarship Fund.

**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 taken by; Sarah Tapscott 2019.

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.

## Young Researcher Travel Award Report (YRTG)

**Franz Lutz** University of Auckland
European Geosciences Union (EGU) General Assembly 2019, Vienna, Austria.

I am a doctoral student at the School of Environment, University of Auckland and my PhD research title is “The investigation and calibration of englacial seismic properties from surface and borehole seismic data“. My research is focused on investigating methods to constrain ice shelf anisotropy and temperature from the propagation of seismic waves in ice.

With the support of GSNZ’s Young Researcher Travel Grant I attended the 2019 EGU General Assembly, which was my first international conference and provided me with an opportunity to present results of my PhD research to an international audience, among which many world-leading scientists in the field of cryospheric sciences are found. The conference took place between the 7th and 12th of April 2019 at the Austria Centre in Vienna and was attended by more than 16000 scientists from 113 countries and a wide range of disciplines in the earth sciences.

As a first-time attendee I participated in EGU's mentoring programme that aims to bring together students and early career researchers with established scientists in their field of research. The General Assembly was kicked off by an ice breaker event on Sunday evening, where a first mentoring meeting took place and I had the opportunity to meet several researchers of EGU's cryosphere division, many of whom I would meet again on several occasions during the conference and at my presentation.

Next to the large number of fascinating presentations between Monday and Friday, the EGU conference offered networking sessions in the evenings, a job forum, a large number of events directly aimed at early career scientists, like a career paths panel discussion, and a number of "Great Debates" about topics of general interest, like "Should scientific publishers be forced to go Open Access?".

Conference presentations were given in the classical oral and poster formats and the relatively new PICO (Presentation of Interactive Content) format, which was the presentation format of my session. My presentation with the title "Constraining ice anisotropy and temperature from active source borehole seismology in the Ross Ice Shelf" consisted of a two-minute skit in front of the session audience, followed by a 105-minute time window with presentations at interactive video screens where each presenter can be approached by anyone interested to hear about the topic in more detail. During this interactive session I had some very fruitful discussions and I found the PICO format a great way of combining the strengths of an oral and poster presentation, as it practically has no limitation on how much content and detail to include but also offers a lot of time for discussion.


Overall, travelling to EGU was a great experience and I am very happy to have been given the opportunity to attend the conference in beautiful Vienna and the exposure and feedback it created for my research, especially in combination with the mentoring programme.

**Focus on the Jurassic: the 7$^{th}$ Symposium of IGCP 632**

Held during 2018 Geosciences, Napier (GSNZ annual conference)

Hamish Campbell and Neville Hudson

The 7th Symposium of IGCP 632 ('Continental crises of the Jurassic') was very stimulating with 25 oral presentations and four posters over three days (28-30 November 2019). There were six key-note speakers: Baoyu Jiang (China), Rie Hori (Japan), Manuel Rigo (Italy), Jingeng Sha (China), Nick Mortimer (NZ) and Yanhong Pan (China). At least 35 participants, mainly palaeontologists and stratigraphers, attended from 8 countries: China, Argentina, Sweden, USA, Italy, Japan, Russia and New Zealand. Many members of GSNZ also attended. The Symposium was convened by Hamish Campbell (GNS Science) and Neville Hudson (School of Environment, University of Auckland).

The meeting was called for by its leaders: Jingeng Sha and Vivi Vajda, and it was significant because IGCP 632 has now reached the end of its natural life (a 3-year project funded by UNESCO). This was one of the largest meetings to be held in New Zealand in recent years with such a strong palaeontological component. It was also unusual in having such a specific focus on the Jurassic. Oral papers were given (in order) by: Baoyu Jiang, Bainian Sun, Rie Hori, Chunlin Sun, Zhiyu Yi, Yu Wang, Hongwei Kuang, Valery Vuks, Manuel Rigo, Jingeng Sha, Lydia Tackett, Miguel Mancenido, Neville Hudson, Greg Browne, Shenghui Deng, Hamish Campbell, Susana Damboranea, Ian Raine, Vivi Vajda, Nick Mortimer, Xin Rao, Yanhong Pan, Yaqiong Wang, Steve McLoughlin and Don MacFarlan.

The seven-day post-conference excursion (FT6; Friday 30 Nov to Thursday 6 Dec) with 24 participants was also a great success. Everything went according to plan. The party comprised 16 from China, three from Argentina, two from Sweden and one from Russia…plus the two New Zealand leaders and drivers: Hamish Campbell and Neville Hudson. We stayed in Taihape, Taupo, Waitomo, Kawhia and Tuakau, traversing the Taupo Volcanic Zone, Kaweka, Murihiku and Waipapa terranes. The two Hertz rentals (Toyota Hiace, 12-seater) were outstanding, with ample luggage space.

The party included three couples: Miguel Manceñido & Susana Damboranea (Natural Sciences Museum, La Plata, Argentina); Vivi Vajda & Stephen McLoughlin (Swedish Museum of Natural History, Stockholm, Sweden); and Enpu Gong & Hongying Yang (Department of Geology, Northeastern University, Shenyang, China). Six single women: Hongwei Kuang (Institute of Geology, Chinese Academy of Geological Sciences, Beijing); Yanhong Pan (Nanjing Institute of Geology and Palaeontology, Nanjing); Xin Rao (Nanjing Institute of Geology and Palaeontology); Yaqiong Wang (Nanjing Institute of Geology and Palaeontology); Yueting Xie (China University of Geosciences, Beijing); and Liyun Zhou (China University of Geosciences, Beijing). Twelve single men: Javier Echevarriá (Natural Sciences Museum, La Plata, Argentina); Changqin Guan (Department of Geology, Northeastern University, Shenyang); Jinhua Hao (China University of Geosciences, Beijing); Baoyu Jiang (School of Earth Sciences and Engineering, Nanjing University); Jingeng Sha (Nanjing Institute of Geology and Palaeontology); Bainian Sun (School of Earth Science, Lanzhou University, Lanzhou); Chunlin Sun (Jilin University, Changchun, China); Valery Vuks (A.P. Karpinsky Russian Geological Research Institute, St Petersburg, Russia); Yu Wang (China University of Geosciences, Beijing); and Zhiyu Yi (Institute of Geology, Chinese Academy of Geological Sciences, Beijing).

The weather during FT6 was inclement on Days 1, 2, 3 and 7, precluding good visibility of the volcanoes (Ruapehu, Ngauruhoe, Tongariro) and a proposed walk up Mount Tauhara near Taupo but in general we dodged any heavy rain showers. The key days of the excursion (Days 4, 5 & 6), within the Murihiku Terrane, were fine and sunny. Yay! All geological imperatives were met.

While in Kawhia (Day 5, Tues 4 Dec), Hamish Campbell gave a public talk in the Kawhia Sports Centre on the 'Geological origins of Kawhia Harbour'. There were more than 90 participants. Not bad for a small rural community! This was a valuable exercise and enabled local people to meet us and learn about our specific geological interests in the Kawhia area. It also provided a great opportunity for our overseas colleagues to experience some classic NZ country culture. The talk was organised by John Thomson, Director of the Kawhia Museum.

There were two commercial voyages: 1) Day 5 on Kawhia Harbour, travelling from Kawhia to Te Maika and back on *Kotuku* with Honey (skipper); and 2) Day 7 on the Hauraki Gulf, travelling from Kawakawa Bay to Pakihi Island and back on *Motunau III* (a barge) with David Chamberlin (skipper).

Cultural/tourism experiences included visits to: Huka Falls, Wai-o-Tapu, Waitomo Caves, Kawhia Museum; Taihape, Whakapapa, Turangi, Taupo, Rotorua, Waitomo, Te Kuiti, Awakino, Kiritehere, Marokopa, Kawhia, Te Maika, Raglan, Nikau Cave, Port Waikato, Tuakau, Kawakawa Bay, Pakihi Island.

The last day of FT6 (Day 7), commenced with breakfast at 'Chez Bean' in Tuakau, and a visit to Pakihi Island (Waipapa Terrane; Tr-Jr boundary sequence) with a number of notable geological guests: Bernhard Spörli, Virginia Toy and Bruce Hayward. Farmers and co-owners of Pakihi Island John & Clare McCallum were also with us.

FT6 greatly benefitted from the science input of Ian Raine and Don MacFarlan, and logistic support from GSNZ, namely Cecile Massiot, Jenni Hopkins, Sarah Milicich, Matt Sagar and Janet George.

Photo taken by Hamish Campbell on the last day (Day 7, Thursday 6 December), on the barge (*Motunau lll*) in Kawakawa Bay after having returned from Pakihi Island.

Field tripping. (Images from http://www.igcp632.org/index.php/news/85-the-second-circular-of-the-7th-symposium-of-igcp-632-in-2018-is-released-now )

## University of Canterbury Update on Student Theses

Alex Nichols alex.nichols@canterbury.ac.nz

Note:
Students sometimes place an embargo on their thesis, to give them time to publish the material, for example. The UC policy is that only the title of an embargoed thesis can be published. In view of this I have provided a list of titles for students who have completed in the last year and, if their thesis is not under embargo, the abstract. I have also provided the details, including the abstract, of students whose embargo has ended within the last year.

**Student: Alison Jolley** (alisonjolley@gmail.com)

Senior supervisor:
Ben Kennedy (ben.kennedy@canterbury.ac.nz)
(Department of Geological Sciences, University of Canterbury)
Supervisory team:
Sam Hampton (Frontiers Abroad Aotearoa Ltd, Christchurch and Department of Geological Sciences, University of Canterbury)
Erik Brogt (Academic Services Group, University of Canterbury)
Lyndon Fraser (Department of Sociology & Anthropology, University of Canterbury).

Thesis Title:
**Student experience and sense of place on geoscience field trips**

**Abstract**:
Field education is a vital component of undergraduate degree programmes in geoscience, but many aspects of this experience are not well understood. The experience of the individual student during a field trip is strongly influenced by affective factors (emotion, motivation, and connection to Earth). How these factors interact in the context of different field trips is poorly understood. This thesis aimed to address how students connect to the locations of their field trips, by investigating their sense of place in a variety of teaching and learning environments. Mixed-methods approaches were used to compare different styles of field education in three studies: (1) field pedagogy/structure, (2) instructor and weather, and (3) student nationality/programme.
Study 1 findings show that on average, students significantly increased in their attachment to the situated field area and had no change in their attachment to the roadside field area. The situated field trip utilised more student-centred pedagogy and student perceptions of learning were closely aligned with instructor intentions. The roadside field trip was less student-centred, did not involve a regional-scale assessment, and students felt spatially disoriented in the field area. Student perceptions were not as closely aligned with instructor

intentions on the roadside field trip. Additionally, the situated assessment allowed instructors to model landscape appreciation, whereas the discrete roadside assessments were less supportive of regional geological connections. Findings from study 2 show that on average, students on all field trip streams had significant increases in their place attachment. There were no significant differences in attachment between streams, despite variations in instructor pedagogy. Instructors had consistent learning outcomes and valued the field area for its educational opportunities, both of which were clear to students. Inclement weather had no significant impacts on students' sense of place or field experience. The field trip assessment was connected to the landscape and had in-built flexibility for the influence of external factors. Instructors also adjusted student autonomy in response to varied weather conditions.

Study 3 findings indicate that on average, 'Study Abroad' students were significantly more intrinsically motivated, placed significantly more task value on the field trip, and had significantly lower test anxiety. 'Study abroad' and local students had no significant differences in their control of learning beliefs and self-efficacy for learning and performance. On average, study abroad students were more pro-environmental (though not statistically significant), and had significantly higher place attachment and place meanings towards the field area. Based on these studies, a new conceptual model for field trips was developed, highlighting the interrelationships between: (a) the individual student, (b) their peer group, (c) their instructor(s), (d) the landscape (field area), and (e) the field trip assessment. This model may be used when designing or modifying field pedagogies by adjusting these interrelationships. Specific recommendations are made for each of the contrasting field educational cases: (1) Situated field trip curricula should maintain aspects of autonomy and assessment integrated with the field area. Roadside field curricula would benefit from ensuring that students are encouraged to discover regional connections for themselves, and we recommend that this is supported through the assessment structure. (2) To support resilience of field trips to differing instructors and weather, it is important that instructors value field education, have similar intended learning objectives that are clear to students, appreciate the field area for its educational features, and exercise flexibility in the assessment structure. (3) Student outcomes on study abroad field trips may be enhanced by more applied, environmentally-focused, or place-based curricula. Curricula should be adapted with a specific audience in mind, rather than applying local field trips without consideration.
The thesis highlights ways in which student connections with field places may be strengthened to better address learning outcomes and develop more environmentally and socially conscious graduates.
Link: http://hdl.handle.net/10092/14554

**Student**: Thomas Garden (thomas.o.garden@gmail.com)

Senior supervisor:
Darren Gravley (darren.gravley@canterbury.ac.nz)
(Department of Geological Sciences, University of Canterbury)
Supervisory team:

Ben Kennedy (Department of Geological Sciences, University of Canterbury)
Chad Deering (Department of Geological and Mining Engineering and Sciences, Michigan Tech, USA)
Isabelle Chambefort (GNS Science)

Thesis Title:

**Calderas and their volcano-tectonic controls on hydrothermal fluid transport**

**Abstract**:

Silicic caldera volcanoes are often spatially associated with hydrothermal systems that are economically important for geothermal power and the localisation of ore deposits, and also influence their restless behaviour and associated hazards. However, despite their potential importance, the influence that caldera-related structures, lithologies and magmatism have on controlling hydrothermal fluid pathways, and the physiochemical conditions of the fluid is not fully understood. Ancient, exhumed calderas provide an opportunity to examine fossil fluid pathways in a more complete structural, lithological and magmatic context than is possible in poorly-exposed modern calderas. In this thesis I use a combination of field mapping, scanline transects, reflectance spectroscopy, alteration mineralogy, vein textures and fluid inclusion microthermometry to reconstruct and better understand the volcanotectonic controls on hydrothermal fluid flow at the 22.9 Ma Lake City caldera in Colorado, U.S.A.

Field mapping, scanline transects and petrographic analyses are used in Chapter 2 to characterise the architecture of the caldera margin and the structural and lithological controls on the distribution of veins and alteration at Lake City. The caldera margin consists of relatively straight segments linked by more structurally complex intersections; these structural intricacies produce a zone of deformation that can reach >300 m wide. Structural analyses show that the wide (up to ~60 m) fault core of the ring fault contains abundant subparallel veins, with orientations similar to that of the caldera margin. Smaller displacement faults inside the caldera generally have narrow (<1 m), hydrothermally cemented fault cores with more variably oriented veins in the surrounding damage zone. These field data suggest that fluid flow is controlled by fault connectivity, the location and displacement of faults, and lithology. I propose a conceptual model where permeability is enhanced by: 1) the presence of permeable lithologies, 2) a high density of faults and fractures, and 3) orientations of faults and fractures that promote the formation of permeable discontinuity intersections.

Secondary alteration minerals form due to interaction between country rock and hydrothermal fluid. Mineral assemblages and compositions can be used to estimate physiochemical parameters of the hydrothermal system (e.g. pH, temperature, water/rock ratio) that are important for geothermal and ore exploration. The composition of hydrothermal white mica is sensitive to changes in physiochemical conditions. Short wave infrared (SWIR) reflectance spectroscopy is a well-established tool for investigating alteration mineralogy, including white mica composition. However, the newest high spatial resolution, automated systems, such as the Corescan HCI-3, are poorly represented in the

literature compared to older low spatial resolution systems, such as the ASD TerraSpec. In Chapter 3, I compare the performance of Corescan and TerraSpec SWIR systems in measuring the composition of white mica, as estimated using the wavelength position of the ~2200 nm AlOH absorption feature (lAlOH). The Corescan and TerraSpec correlate well with each other, although there are small absolute differences that should be taken into account if combining data from both systems. The Corescan results for lAlOH correlate slightly better than TerraSpec with the aluminium content of white mica as determined by scanning electron microscope (SEM) energy-dispersive x-ray spectroscopy (EDS). The spatial distribution of white mica composition at Lake City caldera suggests that high-Al white mica generally correlates with quartz-sericite-pyrite alteration and low d18O compositions in the centre of the caldera, although there are significant deviations from this pattern on the western caldera margin. These results confirm the usefulness of SWIR reflectance spectroscopy and white mica composition as a tool for studying hydrothermal alteration.
infrared (SWIR) reflectance spectroscopy is a well-established tool for investigating alteration mineralogy, including white mica composition. However, the newest high spatial resolution, automated systems, such as the Corescan HCI-3, are poorly represented in the literature compared to older low spatial resolution systems, such as the ASD TerraSpec. In Chapter 3, I compare the performance of Corescan and TerraSpec SWIR systems in measuring the composition of white mica, as estimated using the wavelength position of the ~2200 nm AlOH absorption feature (lAlOH). The Corescan and TerraSpec correlate well with each other, although there are small absolute differences that should be taken into account if combining data from both systems. The Corescan results for lAlOH correlate slightly better than TerraSpec with the aluminium content of white mica as determined by scanning electron microscope (SEM) energy-dispersive x-ray spectroscopy (EDS). The spatial distribution of white mica composition at Lake City caldera suggests that high-Al white mica generally correlates with quartz-sericite-pyrite alteration and low d18O compositions in the centre of the caldera, although there are significant deviations from this pattern on the western caldera margin. These results confirm the usefulness of SWIR reflectance spectroscopy and white mica composition as a tool for studying hydrothermal alteration.

Link: [http://hdl.handle.net/10092/15068](http://hdl.handle.net/10092/15068)

**Student**: Josh Borella (josh.borella@pg.canterbury.ac.nz)

Senior supervisor:
Mark Quigley (mark.quigley@unimelb.edu.au)
(School of Earth Sciences, University of Melbourne, Australia)
Supervisory team:
Darren Gravley (Department of Geological Sciences, University of Canterbury)
Jarg Pettinga (Department of Geological Sciences, University of Canterbury)

Thesis Title:
**Geologic and anthropogenic influences on rockfall and liquefaction in the 2010-2011 Canterbury earthquakes and their prehistoric predecessors**

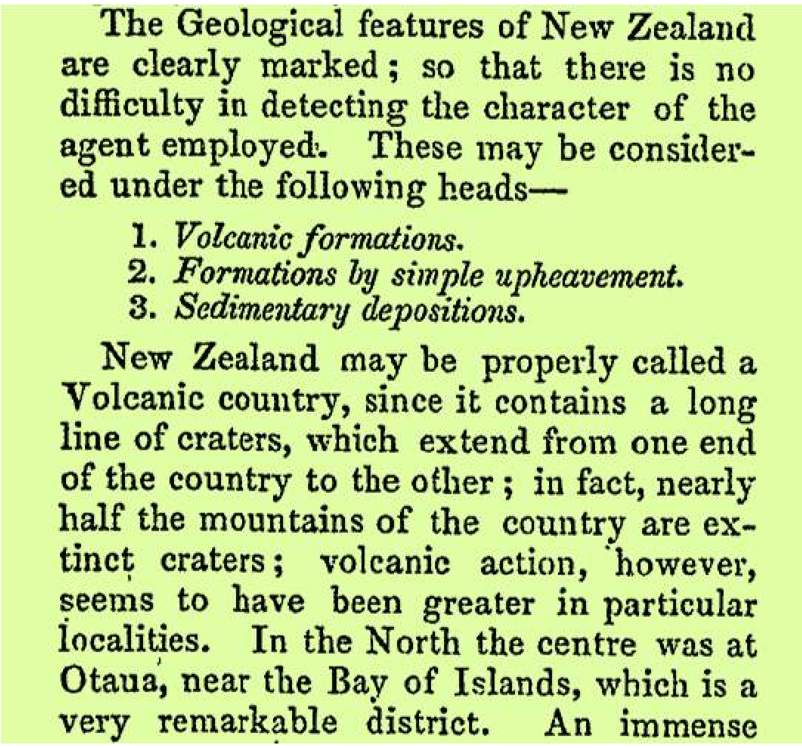
Thesis under embargo until 27 June 2019.
Link: http://hdl.handle.net/10092/13616

**Student**: Stanley Mordensky
(stan.mordensky@gmail.com)

Senior supervisor:
Ben Kennedy
(ben.kennedy@canterbury.ac.nz)
(Department of Geological Sciences, University of Canterbury)
Supervisory team:
Marlene Villeneuve (Department of Geological Sciences, University of Canterbury).
Darren Gravley (Department of Geological Sciences, University of Canterbury)

Thesis Title:
**Effects of magmatic intrusions on the mechanical and physical properties of volcanic host rock: Pinnacle Ridge, Mt. Ruapehu, New Zealand**

Thesis under embargo until 16 April 2020
Link: http://hdl.handle.net/10092/16628



The Geological features of New Zealand are clearly marked; so that there is no difficulty in detecting the character of the agent employed. These may be considered under the following heads—

1. *Volcanic formations.*
2. *Formations by simple upheavement.*
3. *Sedimentary depositions.*

New Zealand may be properly called a Volcanic country, since it contains a long line of craters, which extend from one end of the country to the other; in fact, nearly half the mountains of the country are extinct craters; volcanic action, however, seems to have been greater in particular localities. In the North the centre was at Otaua, near the Bay of Islands, which is a very remarkable district. An immense

Otago Witness (297) **August 8, 1857**.

**Student**: Alan Bischoff
(alan.bischoff@canterbury.ac.nz)

Senior supervisor:
Andy Nicol (andy.nicol@canterbury.ac.nz)
(Department of Geological Sciences, University of Canterbury)
Supervisory team:
Mac Beggs (New Zealand Oil & Gas Ltd)
Darren Gravley (Department of Geological Sciences, University of Canterbury)
Ben Kennedy (Department of Geological Sciences, University of Canterbury)

Thesis Title:
**Architectural elements of buried volcanic systems and their impact on geoenergy resources**

**Abstract**:
This PhD investigates the architecture of volcanic systems buried in New Zealand sedimentary basins. These "fossil" volcanoes occur in great numbers around the globe, typically comprising complex magmatic-sedimentary systems that produce large impacts in the evolution of the host sedimentary basin. The interaction between magmatism and sedimentation creates a range of geological conditions that can favour the occurrence of geoenergy resources, such as hydrocarbons and geothermal energy. Interpretation of volcanoes in the subsurface requires a multidisciplinary approach that combines insights from complementary disciplines, such as sedimentology, stratigraphy, and volcanology into a unified model. Over the last two decades, knowledge of volcanic systems in sedimentary basins has increased significantly, largely due to improvements in the quality and availability of seismic reflection data. This PhD research uses data from 2D and 3D seismic reflection surveys to characterise the spatio-temporal distribution of the fundamental building blocks (i.e. architectural elements) of buried volcanic systems, aiming to provide insights for exploration of geoenergy resources. Here, we divide the stratigraphic record of these "volcanic basins" into three first-order magmatic sequences (i.e. pre-, syn- and post-magmatic), which can be sub-divided into second-order magmatic stages related to the emplacement, construction, degradation and burial of the volcanoes.

Two case-study areas have been utilised to determine how the architectural elements vary systematically in buried monogenetic and polygenetic volcanic systems. These study areas are the Kora Volcanic System (KVS) and Maahunui Volcanic System (MVS), located in the Taranaki and Canterbury basins respectively. Both volcanic systems formed in marine environments during the Miocene, and show systematic spatio-temporal distributions of architectural elements. In both cases, each one of the magmatic sequences and stages are characterised by a network of genetically related architectural elements, formed by interactions between intrusions, eruptions and sedimentation. Syn-intrusive architectural elements are formed by magma emplaced into the host basin strata (emplacement stage), and include hypabyssal intrusions such as sills, dikes and

small plutonic bodies, together with associated deformed strata. Syn-eruptive and inter-eruptive architectural elements are formed during the constructional stage, and include all primary eruptive, epiclastic, and associated sedimentary deposits formed during active and quiescent volcanism. Post-magmatic architectural elements are formed during the passive degradational and burial stages of volcanism, comprising sedimentary deposits impacted by the presence of volcanic structures, which can influence sedimentation millions of years after complete burial of volcanic edifices.
In detail, the architectural elements of each volcanic system also display differences. Dikes and sills of the KVS plumbing system typically formed along, or branching from, simultaneous Miocene rift faults. Explosive submarine volcanism in Kora formed a large-volume (ca 95 $km^3$) basaltic-andesitic compound volcano erupted from a fixed central conduit, which dominated seafloor topography and created localized debris deposits that interfinger with hemipalagic sediments and deep-water channel deposits. In contrast, the monogenetic MVS plumbing system distributed magma to dispersed eruptive centres, which formed small-volume (< 6 $km^3$) basaltic submarine volcanoes equivalent of maar-diatreme and tuff cones erupted at ca 1000 m depth. Degradation of volcanoes in the MVS was differential, with strong erosion on the top of shallower and higher edifices that were emergent above sea-level during a late Miocene base-level fall, while volcanoes that remain below the sea-level were not subject to significant degradation and are now well preserved beneath bathyal sediments.

Analysis of the architectural elements of the KVS and MVS provide insights into the exploration of geoenergy resources in buried and active volcanic systems elsewhere. Intrusions and magmatic deformation, including large saucer-sills and intrusion swarms, have the potential to produce four-way closures and reservoirs that can host significant oil and gas accumulations. These intrusions can also produce high-temperature intrusion-related geothermal systems. Both petroleum and geothermal systems can be enriched in $CO_2$, $CH_4$, and $H_2S$ if the intrusions were emplaced in carbonate or organic-rich host rocks. Eruptive and sedimentary architectural elements can form substantial hydrocarbon fields with reservoirs in paleogeomorphic structures formed by changes in lithologies and by the presence of stratigraphic discontinuities between the volcano and enclosing sedimentary strata. Syn-eruptive reservoirs can be sealed, if volcanic structures are buried by fine-grained marine sediments or evaporitic rocks. Progressive burial of the volcanoes can create ideal conditions for deposition of high-quality carbonate reservoirs located on topographic seabed highs above buried volcanic structures. Due to differential compaction between the volcanoes and enclosing sedimentary rocks, these carbonate reservoirs can be entrapped in large four-way closures, with potential to host world-class hydrocarbon fields. Therefore, analysis of volcano-stratigraphic architecture of buried volcanoes can be used to build models for the exploration of geoenergy resources such as hydrocarbons and geothermal electricity.

Link: http://hdl.handle.net/10092/16730

**Student**: Alistair Davies (alistair.davies@pg.canterbury.ac.nz)

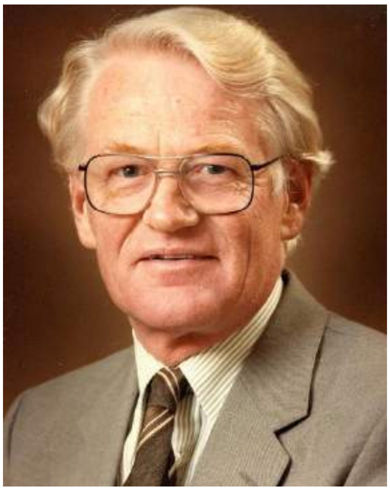
Senior supervisor:
Thomas Wilson (thomas.wilson@canterbury.ac.nz)
(Department of Geological Sciences, University of Canterbury)
Supervisory team:
Tim Davies (Department of Geological Sciences, University of Canterbury)
Sarah Beaven (Department of Geological Sciences, University of Canterbury)
Liam Wotherspoon (Civil and Environmental Engineering, University of Auckland)

Thesis Title:
**Increasing the disaster resilience of remote communities through scenario co-creation**

Thesis under embargo (just completed, no link currently available)

## OBITUARIES

### David Kear (1923-2019)



*Compiled by Simon Nathan, with input from the Kear family, Steve Edbrooke, Bruce Hayward, Cam Nelson, David Skinner and Ian Speden*.

David Kear died recently in Auckland, aged 95. He was Director of the New Zealand Geological Survey from 1967-74 when he was appointed assistant Director-General of the Department of Scientific and Industrial Research (DSIR). He was later Director-General from 1980 until 1983 when he retired.

In his career as a geologist and science administrator, David made a major contribution to the knowledge and utilisation of New Zealand's mineral resources and the application of science to practical problems.

Born in London, David Kear was educated at Sevenoaks School, where he was head boy. Awarded a scholarship to the Royal College of Mines at Imperial College, he completed a degree in mining engineering, including several months practical experience in south Wales coal mines. He later said that this convinced him that he did not want to spend his life working underground. He spent the later part of the war and its aftermath, from 1944-47, in the Royal Navy. During this period, he served on a number of ships including HMNZS *Archilles*, and visited Australia and New Zealand. Returning to Imperial College for postgraduate study in geology, he applied for a job he saw advertised with the New Zealand Geological Survey. Before leaving England, he married Joan Bridges, and they spent their honeymoon on a five-week sea voyage to New Zealand.

When the Kears arrived in New Zealand late in 1948, there was a major post-war energy shortage. Much of the work of the Geological Survey was concentrated on coalfield investigations. Initially posted to Greymouth, David and Joan Kear spent their first summer investigating the coal resources of the Murchison area with Pat and Daphne Suggate. A few months later this was followed by a transfer to Ngaruawhia to investigate the Waikato coalfields in conjunction with Jim Schofield and later Barry Waterhouse. It was the start of a highly productive scientific period when David produced many reports, maps and publications. A natural leader, he was immediately appointed District Geologist, and throughout his career he always had administrative responsibilities which he carried out efficiently.

Initially investigations at Ngaruawahia focussed on detailed mapping of the Waikato coalfields and estimation of coal resources, and David was always proud that this work provided the basis for the Meremere and Huntly power stations. Subsequently the scope of their work expanded to include regional geological mapping of the area around Hamilton, eventually published as the Ngaruawhia subdivision (NZGS Bulletin 88). In conjunction with Charles Fleming, David spent periods mapping fossiliferous Jurassic rocks around Kawhia (NZGS Bulletin 67). In 1956 David Kear and Bryce Wood spent three months undertaking a reconnaissance survey of Western Samoa, aimed at locating groundwater resources (NZGS Bulletin 63). Over the years David was to return to Samoa many times to assist with groundwater investigations.
In addition to these and other activities, David enrolled for an external PhD from the University of London, and spent many weekends and holidays studying the geology of the Te Akau area, west of Hamilton. His PhD was awarded in 1964.

In 1957 Dick Willett, newly appointed as Director of the Geological Survey, initiated a 10-year crash programme to produce a new 1:250,000 geological map of New Zealand. This took priority over all but the most urgent economic projects. Staff from Ngaruawahia moved to an expanded Auckland office at Otara in 1958, and David Kear was again District Geologist, now responsible for the mapping of the upper part of the North Island. He quickly completed the Hamilton sheet, incorporating most of the work that had already been done, and filling in the gaps. He then moved to Northland, working in conjunction with Bob Hay, to complete the North Cape sheet. He was also involved in some of the early exploration of the Ngawha geothermal field. David was starting to develop ideas that there had been large-scale overthrusting of older rocks over younger sequences in Northland, based on drillhole results, but Bob Hay was adamantly opposed. In later years, David ruefully recalled that the North Cape map was an inconsistent patchwork, depending on which geologist had interpreted particular areas. He was pleased that the concept of the Northland Allochthon had become widely accepted a few decades later through the work of a younger generation of geologists.

The development of a New Zealand steel industry, based on the widespread titanomagnetite sands along the west coast of the North Island, had long been delayed by technical difficulties. In 1960 the government set up the New Zealand Steel investigating company, with directors from the private and public sector. A number of DSIR staff were seconded to the company including David Kear, whose immediate job was to find a deposit of ironsand with over 80 million tonnes of high-grade concentrate close to suitable transport – a challenging problem as earlier surveys had concluded that such a deposit did not exist. Based on his PhD work around Te Akau, David reasoned that such a deposit might be found on a raised interglacial terrace, but be covered by recent dunesand. His logic proved correct, and a suitable deposit was subsequently proved up by drilling at Waikato North Head. Finding a suitable site with solid foundations for the steel mill itself was more difficult because of the widespread presence of peat in the Waikato valley. Using geological maps, David found a suitable site at Glenbrook on old lava flows.

Formation of an interdepartmental Mineral Resources Council in 1963 led to recommendations for a major increase in investment in the mining industry, including an increase in DSIR work in different fields. This led to the appointment of David Kear as Chief Economic Geologist, responsible for all economic and applied geology within the Geological Survey. In 1965 the Kear family moved from Auckland to Lower Hutt. Two years later, when Dick Willett transferred to DSIR Head Office, David Kear was appointed as Director of the Geological Survey. In 1973 he was elected a Fellow of the Royal Society of New Zealand.

During the preceding decade, the 1:250,000 mapping programme had taken priority over everything else, so when David took up his new position there were some long-term issues that needed attention. In particular, there was a huge backlog of manuscripts awaiting publication, and with his active encouragement a record number of maps and NZGS bulletins were published in the next five years. New groups focussing on applied geology were set up, including engineering geology (under Les Oborn), earth deformation (under Gerald Lensen) and petroleum (under Rudi Katz). Offshore drilling for petroleum started in 1970, and led to an expansion in paleontological services for the oil industry. David Kear administered with a light touch and delegated responsibility to his senior staff. The organisation ran smoothly under his directorship. He was helped by the fact that it was a period of prosperity, without financial cutbacks.

In 1974 David was appointed assistant Director-General of DSIR, and in 1980 he became Director-General, responsible for a large and diverse scientific organisation. In conversation after his retirement, he recalled that this was a complete change in direction and he was suddenly dealing with issues that had never concerned him previously. For example, one of his first tasks was to represent DSIR at the hearings of the Royal Commission on Nuclear Power, which involved a crash course in the scientific issues involved.

The period he spent at DSIR Head Office coincided with a series of energy crises in the 1970s and 1980s. This led to the "Think Big" projects developed by the Muldoon government under energy minister Bill Birch, most of which required scientific input and evaluation. David played a leading role in the formation of Petrocorp, the state-owned exploration company, leading to the discovery of oil at the McKee field. This was particularly satisfying to the local geological community, as the oil companies up to that time had maintained that New Zealand was a gas province, and therefore not worth exploring for oil.

Although David Kear was working effectively as a senior Departmental head, he reached the compulsory public service retirement age of 60 in 1983. It was a waste of a competent administrator, but David commented a decade later that he had few regrets, especially as he escaped the impact of major government restructuring in the late 1980s and 1990s. In the 1983 Queen's birthday honours, David was appointed a Companion of the Order of St Michael and St George (CMG).

Joan and David Kear had already decided that they would retire to Ohope, the beach suburb of Whakatane, where they built a home that they lived in for the next 30 years. David continued to do some consulting work, both in New Zealand and overseas for a few years, and he and Joan entered fully into the life of their local community, for example as foundation members of the Whakatane Probus Club and Friends of the Whakatane Museum. David wrote a number of articles on the local geology for a non-technical audience, and had planned to write scientific papers on the tectonic development of the North Island. Unfortunately, this was when the isolation of Ohope became apparent as he had little access to modern literature. He was disappointed that his papers were not accepted for publication, and published several privately. In later years he became sceptical of the evidence for anthropogenic global warming.

Joan Kear died in 2013. David continued to live at Ohope until early 2018, before moving into nursing care at Mercy Parklands in Auckland, close to some of his family. His daughter, Susan Shaw, commented that David enjoyed happy memories from his 'lucky life' (as he put it) that were recorded in a continuous slide show set up his room that reminded him of the many people, places, activities and events that shaped his life.

David Kear was one of the very few living Foundation Members of the Geological Society of New Zealand (formed in 1955), and was an active participant in the early years, serving as the society's youngest president (aged 36) in 1959-60. He also played a leading part in organising the society's first conference held in Hamilton in 1967.

Group of retired Geological Survey staff, taken at the time of the 125th anniversary in 1990. Almost all those pictured had worked at some stage with David Kear. From left: From left: George Grindley, Graham Mansergh, Les Oborn, Norcott Hornibrook, Jim Healy, Pat Suggate, Max Gage, David Kear, Rudi Katz, Gerrit van der Lingen, Bruce Thompson.
Photographer: Lloyd Homer.

David Kear with Pat Suggate

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Kear, D. 2009. Rewards from mineral developments to New Zealand's people and economy. *GSNZ Journal of the Historical Studies Group 37*: 11-52.

Kear, D. 2013. A Kear Twosome, for Joan's memory and our family. Published by David Kear, Whakatane.

Taped interview with David Kear by Simon Nathan. Deposited at Alexander Turnbull Library.

The Kear Collection – a series of self-published articles by David Kear, listed on the GSNZ website at http://www.gsnz.org.nz/information/articles-i-24.html


## *Key publications*

The GNS bibliographic database lists 173 publications by David Kear. The list below gives his key publications, illustrating the variety of his work:


Kear, D. 1959: Stratigraphy of New Zealand's Cenozoic volcanism north-west of the volcanic belt. *NZ Journal of Geology & Geophysics 2(3):* 578-89.

Kear, D., Schofield, J.C. 1959. Te Kuiti Group. *NZ Journal of Geology & Geophysics 2(4):* 685-717.

Kear, D., Wood, B. L. 1959: The geology and hydrology of Western Samoa. *NZ Geological Survey Bulletin 63*, 92 pages + maps.

Kear, D. 1960: Sheet 4, Hamilton. Geological Map of New Zealand, 1:250,000

Fleming, C. A., Kear, D. 1960: The Jurassic sequence at Kawhia harbour, New Zealand. *NZ Geological Survey bulletin 67*, 50 pages + maps.

Kear, D., Hay, R.F. 1961. Sheet 1, North Cape. Geological Map of New Zealand, 1:250,000.

Kear, D. 1966: Sheet N55, Te Akau. Geological Map of New Zealand, 1:63,360.

Kear, D., Schofield, J. C. 1978. Geology of the Ngaruawhia subdivision. *NZ Geological Survey bulletin 88*. 168 pages + maps.

Kear, D., Waterhouse, B. C. 1966. Onerahi chaos-breccia of Northand. *NZ Journal of Geology & Geophysics 10(3):* 629-46.


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## Memories of Trevor Chinn (1937 – 2018)

David Pocknall pockodt@gmail.com

It was with deep sadness that I learned of the passing of Trevor Chinn (Simon Nathan, GSNZ Newsletter, March 2019). The accounts in the links given by Simon provide a comprehensive view of the man, the 'glaciologist-extraordinaire' and his impact on the world of glaciology, especially in New Zealand and Antarctica. I have lived in the US for the past 28 years and unfortunately, I have lost track of former colleagues and friends. In recent years there has been a slew of obituaries of former NZGS colleagues and as time passes their stories will be lost, so I would like to share a little from my brief interaction with Trevor.

Trevor in thoughtful mood, Alatna Valley, Antarctica 1989.

In the winter of 1989, the then head of the NZGS Antarctic mapping program, David Skinner, called me to his office and asked me if I wanted to spend the summer on the ice. The task was to map the Convoy Range, a 2,500 square km area north of the Mackay Glacier, and outside of the Dry Valley area that had been the focus of mapping for many years before. Of course, I said yes, even without consulting with my wife! What geologist would turn down an offer like that. The next words out of his mouth floored me …. he asked me to lead the field party; a paleontologist with a background in palynology being asked to lead a field mapping party to the Antarctic. Of course, I said yes! The team included Richard Sykes (still with GNS), John Skilton (field assistant) and the glaciologist Trevor Chinn. Richard was a colleague in the Lower Hutt office of NZGS and we had worked together, and I had heard of Trevor but never met him.

Our interactions began on his first visit to Lower Hutt to get the project planned. I don't recall whether he stayed with us in our Korokoro home on the first visit, but he did on subsequent visits. He got to spend time with our two sons who were 2 and almost 4 years old. He bought them torches (flashlights) that had interchangeable lenses with multiple batman images. They were a hit with all three of them and led to many nights of them not getting to sleep when the parents wanted them! He was in his element with the boys. The boys room also had stars and planets displayed on the ceiling so Trevor the meteorologist taught them to recognize some of the major elements of our solar system.

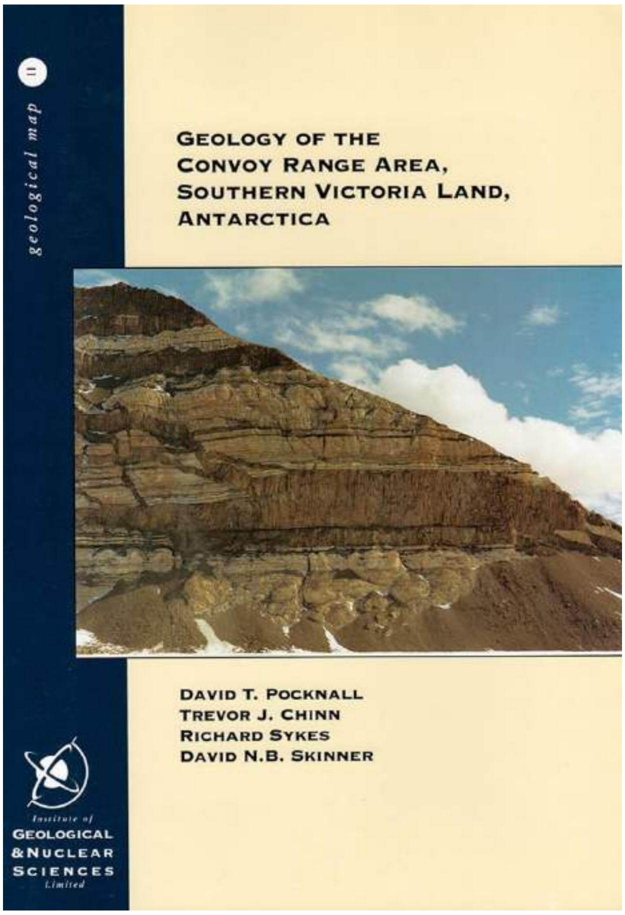
Our shakedown trip was to Mount Roberts near Lake Tekapo for a week in August of 1989 and it soon became obvious that the team was going to learn an enormous amount about "living" on the ice and Trevor would be our greatest ally in the months to come. Planning continued for the next few months and as anyone spending the summer on the ice knows, there was plenty to plan for, another area that we relied heavily upon Trevor.

We arrived at McMurdo on December 4th and after a 36-hour safety induction we were transported to our first camp at the head of the Alatna Valley near the base of Mount Gran. Setting up camp was our first task at hand and Trevor's youthful exuberance was shown when he pulled out of his supply box colorful flags and kites. The gem was his insulated toilet seat, a regular toilet seat but lined with polystyrene, which had huge benefits in an outdoor toilet in -15°C. Trevor maintained that if you are going to have to sit outside to do your business then you had to be comfortable but also have a great view. So, Trevor chose most of our toilet sites!

Trevor Chinn, Richard Sykes, and David Pocknall, New Year's Day, January 1990 (image: David Skinner).

As we got into fieldwork Trevor often worked by himself as he was tasked with mapping the glaciers and the moraines in the Alatna Valley, and other dry valleys in our mapping area. On his return to camp one day he discovered a rusty can. On the same path the next day he found a fork and a crampon which led him to say that he would find the other crampon tomorrow. He did! Eventually after many trips to the site, aided by the whole team, we found the remains of an abandoned camp, dating back to an American field party in January 1961. I captured the story in an article entitled "Supermarket on Ice" (Pocknall 1991) noting that the food we found provided a very tasty supplement to our standard issue dehydrated food.


A sampling from the "Supermarket on Ice".




Throughout our two months on the ice Trevor was a close friend and confidant. Having four guys who really didn't know each other living in a confined space (tents) provided its moments. As team leader I was especially receptive of Trevor's counsel and experience, much of it given while he smoked his favored pipe. If I recall, he had several in his supply box! The success of any trip is the sum of the team input and Trevor was a huge part of our success. The geological map of the Convoy Range was subsequently published (Pocknall et al. 1994).

Richard Sykes, John Skilton, and Trevor Chinn, on the Mackay Glacier, December 1989.

Trevor's son Warren (whom I have not met) described his Dad as "an extraordinary guy, very persistent and dogged, and kept doggedly going and going". I could not agree more. He had an insatiable love of life, working up to his final days. Sadly, Trevor has left us, and I am sad but in his time on our planet he made a huge contribution to our knowledge of glaciers, rivers, and the geology of Antarctica.

RIP my friend and sympathies to his family and friends. He will be missed by all. I would like to thank Glenn Vallender for his assistance in finding my 1991 GSNZ Newsletter article.

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Pocknall, D.T, Chinn, T.J., Sykes, R., & Skinner, D.N.B. 1994. Geology of the Convoy Range Area, Southern Victoria Land, Antarctica. Institute of Geological & Nuclear Sciences Geological Map 11, Scale 1: 50,000. 36 p. (plus map).

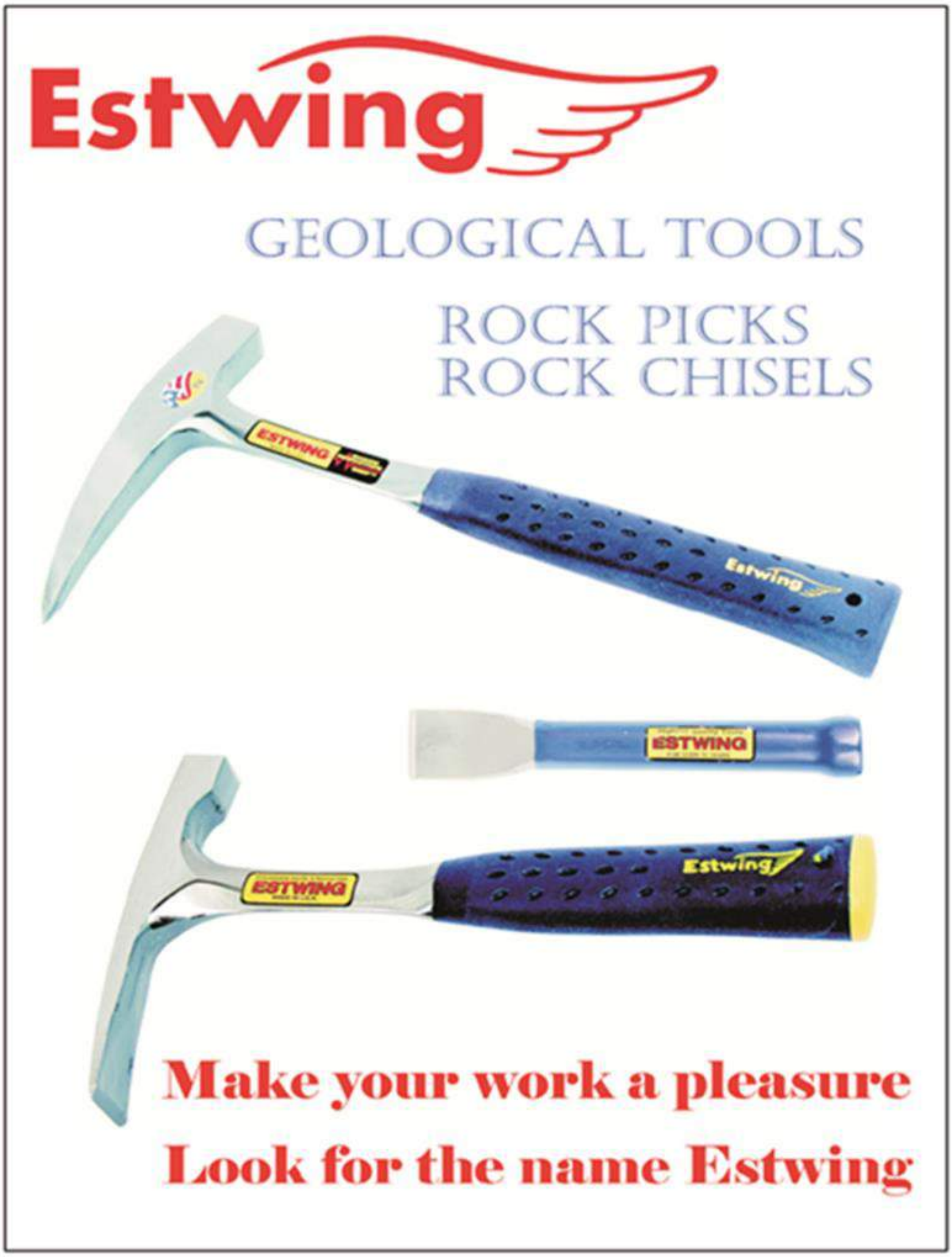

**Further published notes on Trevor(Ed):**

https://i.stuff.co.nz/environment/109932454/life-story-trevor-chinn-the-man-who-saved-glaciology

https://www.nzgeo.com/stories/living-ice/

https://sirg.org.nz/2018/12/21/trevor-chinn-1938-2018/

https://www.pressreader.com/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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.

Email copy in any text format is acceptable. The newsletter is formatted for A5 in Arial 13 with 2.0cm side margins and full justification. Coloured graphics often lose their impact and readability when in greyscale.



Note that names are normally of the format “John Smith” or “Jane Smith”. We prefer not to use titles such as Mr, Dr or Professor, nor to worry about whether we should use Miss, Mrs, or Ms.

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