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ABOUT GSNZ

GEOSCIENCE SOCIETY OF NEW ZEALAND

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Geoscience Society of New Zealand Newsletter - Issue 34

James Scott
President

The Earth sciences have a lot to be pleased about with the Marsden Fund. This Fund is stated to invest "in excellent, investigator-led research aimed at generating new knowledge, with long-term benefit to New Zealand. It supports excellent research projects that advance and expand the knowledge base and contributes to the development of people with advanced skills in New Zealand. The research is not subject to government's socio-economic priorities. The Marsden Fund encourages New Zealand's leading researchers to explore new ideas that may not be funded through other funding streams and fosters creativity and innovation within the research, science and technology system".

Each year millions of dollars are provided to leading geoscientists to develop exciting new research projects, and it is well-deserved; many of the successful projects develop new techniques or lead to new scientific insights. High quality publications are commonly produced and workshops are held. Some of these influence government policy.

The Royal Society Te Apārangi webpage (https://www.royalsociety.org.nz/what-we-do/funds-and-opportunities/marsden/awarded-grants/) states recent Marsden successes. Within the ESA (Earth Science and Astronomy) panel, these can loosely (and very non-scientifically since only the titles are provided) be subdivided into 3 categories: "climate", "natural hazards" (earthquakes and volcanoes) and "other".

In 2020, there were 10 grants awarded, of which 3 fall in the hazards section (all had "earthquake" in the title), 5 are related to climate change (four with "climate" in the title) and two belonging to the "other" category. It is a similar story for 2019; 11 projects were funded, of which 4 were hazard-related, 6 are climate-related, and there was one Astronomy project. In 2018, 11 projects were funded, of which 5 were related to climate-related, 4 were natural hazard-related, and two fall in the "other" category. Statistics on the numbers of ESA applications submitted and the category with which they would fall are not available.

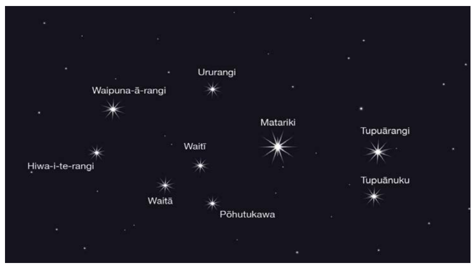
Since the fund is explicitly stated to support long term benefit to New Zealand, it makes sense that climate and hazard-related topics are supported. Indeed, if you were an objective observer and you looked at the ESA Marsden successes as the only measure of what is being researched within ESA in New Zealand, you would probably assume that most of the excellent, investigator-led research undertaken is climate and/or natural hazard-related. Of course, that isn't true; there is vast amounts of research that does not fall in either of those fields. It would be nice to see the Marsden Fund, as stated in its brief, further supporting: "ideas that may not be funded through other funding streams and [to] foster creativity and innovation within the research, science and technology system". Encouragement of applications for smaller amounts would enable more grants to be awarded, which could be a strategy for increasing support for early career researchers. More Marsden successes would enable more people to do higher quality research, which would generate more outputs and more policy changes. This would also lead to an increased long-term benefit by expanding knowledge and developing skills and people in New Zealand.■

Janis Russell
Editor

By the time this issue gets to you all, Matariki celebrations will likely be done and dusted. Many of us will have thrust our gaze upwards and peered out into the cosmos searching for the nine celestial bodies that make up the Matariki star cluster. Matariki and her eight daughters herald the start of a new year, for Māori, and with the introduction of a new public holiday in 2022 we shall all officially celebrate a universally shared heritage— the visible night sky.

This year has already been a good one for exciting space-related phenomena. In February, with hearts aflutter, we watched the Perseverance rover touch down on Mars, with the promise of new geoscientific knowledge likely to be revealed about the red planet's rocks from both crust and mantle. We savoured the rare, super blood moon/lunar eclipse on show, either in person or in shared, stunning images, at the end of May. With the rising of the Matariki cluster in July, I hope you were able to search out and learn the meaning, and names, of those other eight Matariki stars (listed below).

These events are a timely reminder that not all geoscience is Earth science although the names are often used interchangeably. Yet, it is still exciting to see the high resolution images beamed to us from Mars showing the detail of its surface features, sculpted by water and wind, that look like they could be on Earth — old river deltas, ancient lake beds, dunes, and with extraterrestrial rocks that are chemically similar to our own basalts and carbonates, to boot.



It is astonishing that we are able to glean so much information about the composition of celestial bodies, using an array of techniques from right here on Earth. And while the NASA mission, to collect and analyse rock samples from Mars, will provide us with plenty of research material for the years to come, it is an expensive exercise. However, every now and then, some interesting space rock samples come to us free of charge!

In this issue, Joel Schiff has written about some of Aotearoa / New Zealand's meteorites on page 32. Looking ahead to the issue for July 2022, we can certainly cast our eyes beyond Earth, so I will be seeking several articles for a feature section on planetary geology. ■

Matariki Stars:

Matariki: reflection, hope, connection to nature, and the gathering together of people and well being [CONNECTION and CARE]

Pōhutukawa: constant reminder of our treasured ones who have passed on [REMEMBRANCE]

Waitī: associated with fresh water and the food sources sustained by them [FRESH WATER]

Waitā: associated with the ocean and food sources within it [OCEAN]

Tupuānuku: associated with everything that grows within the soil to be harvested or gathered for food [SOIL]

Tupuārangi: associated with everything that grows in the forest — fruit, berries, birds [FOREST]

Waipuna-ā-rangi: associated with the rain that brings new growth and helps people flourish [RAIN]

Ururangi: associated with refreshing and revitalising winds [WINDS]

Hiwa-i-te-rangi: associated with the granting of wishes and realising our aspirations for the coming year [FUTURE]

THE STRANGE CASE OF NIUE ISLAND NATURAL RADIOACTIVITY

Neil Whitehead and Paul Aharon

Summary

The uplifted atoll of Niue Island is located 2500 km NE of New Zealand. In the late '50s it was found to have soils with high natural radioactive levels which led many to wonder if there was a buried uranium deposit. None has been found in spite of drilling. Current thinking is that the soils accumulated uranium in groundwater or perhaps seawater, daughter products in-grew, then the uranium was leached away in a time of intensified rainfall and more oxidising conditions. Contrary to usual geochemical prospecting models this does not imply a uranium deposit nearby. The health of the islanders seems the same as for non-radioactive islands.

Prospecting using a soil collection

In the aftermath of Hiroshima, the world's love/hate relationship with uranium led to fevered prospecting. In New Zealand two prospectors, Cassin and Jacobsen, found in 1956 a radioactive trachyte dyke during a comfort stop near Hawk's Crag in the Buller Gorge. The resultant uranium find in nearby breccia was not economic, but led to further prospecting.

The New Zealand Soil Bureau had accumulated over time many soil samples, including from the Pacific Islands and a walk through the soil store with a Geiger Counter, equivalent to surveying many locations for uranium in a brief time, showed that the soils of Niue Island, an uplifted atoll a few hours flight north east of Auckland, were quite radioactive. If this indicated uranium it would have been one of the shortest prospecting trips on record! Niue has no surface igneous rocks and coral never contains high amounts of uranium.

At that time Ernest Marsden, head of the then Department of Scientific and Industrial Research, was about at the age of retirement, and became very interested. With Geiger he had worked under Rutherford, and found the fundamental truth that a very dense nucleus in the atom was surrounded by diffuse electron clouds. He commandeered Niue studies as a kind of retirement project (Marsden et al. 1958; Marsden 1959; Marsden 1960; Marsden 1964). One now-deceased member of Soil Bureau was heard to remark he knew of some other islands with soil radioactivity rather like Niue. But he was not going to mention it, lest studies on them were also commandeered. Unfortunately no-one else knew the name of these islands.

Niue itself has presently only about 1600 inhabitants (but about 20,000 are in Auckland and several thousand in Brisbane). In spite of the low population as an independent nation, it has generally the same government legal apparatus as New Zealand, including an Atomic Energy Act!

Using his numerous scientific links with the United Kingdom, Marsden found in preliminary tests that the major source of the radioactivity was not uranium or nuclear fallout from weapons testing, but natural daughters of ^{238}U; ^{230}Th and ^{226}Ra. Also anomalously present in the same way but in much smaller amounts was ^{231}Pa (protactinium), a daughter of the minor uranium isotope ^{235}U. Three major puzzles emerged: (i) had enhanced uranium been present and been leached away; (ii) was there a large deposit somewhere close, and (iii) were there any health effects on Niueans? The radioactivity levels were equivalent to some of the other natural radioactive hot-spots worldwide, like the radioactive southern beaches of India or some areas of Brazil rich in thorium. If the uranium had previously been present it would have been equivalent to about 1000 mg.kg^{-1}, ore-grade.

Laboratory work

The Soil Bureau, in an extensive series of studies on Niue, analysed about 100 samples of soils for major and trace elements and trace minerals. They also did geochemical studies and fertility trials. The red lateritic soils contained predominantly iron and aluminium compounds, and had very little silica, showing extreme weathering. It was the soils which contained the anomalies, and underlying coral contained almost none (e.g. Edwards 1957; Fieldes et al. 1960; Schofield 1967; Whitehead et al. 1991).

In a brilliant piece of work, Marsden modified a Geiger counter so it would directly detect the minor radionuclide ^{231}Pa, or rather two of its daughters, which decay sequentially and very rapidly. Electronic circuits selectively recorded paired impulses from gamma rays occurring in a small fraction of a second. Analysis of protactinium by other means is very difficult, demanding extensive careful radiochemistry. The protactinium seemed to behave the same geochemically as ^{230}Th. Marsden died late in 1970 but the research on Niue soils continued.

For most precise and informative determination of the radioelements, radiochemical isolation was necessary. The Institute of Nuclear Sciences (INS) within DSIR was such a specialist and used the same samples for detailed examination. Most were alpha emitters, and this meant that one must isolate trace or ultra-trace amounts almost pure, otherwise after electroplating for counting, the energies of the peaks during alpha spectrum accumulation would degrade through the presence of accompanying elements. Worse, because the amounts were so small, the extraction must have a high chemical yield. Bill McCabe of the Institute of Nuclear Sciences, a much underappreciated developer of word class radiochemical methods, originated such a method in the 1970's – '80s, whose yields were essentially quantitative and no researchers elsewhere approached the analytical quality for several decades. Quantitative extraction of ^{231}Pa at the ng range from about 10 g of sample was routine, with indetectable accompanying elements. The multi-step process involved several ion-exchange systems. The results were excellent, but very labour intensive, hence expensive. Analysis of many Niuean samples gave results published into the '90s (Whitehead, Ditchburn, et al. 1992; Whitehead, Leslie, et al. 1992).

The uranium in the soils was anomalous; it should be 1-2 mg.kg^{-1} in basaltic laterites (aerially-deposited basalt ash seemed the most likely origin) but Niue soils had a mean of 33 mg.kg^{-1} and highest result 70 mg.kg^{-1} so these unexpected amounts of uranium needed explanation.

The amount of the daughter products was much higher even than those corresponding to the anomalous uranium so there was a remarkable radioactive disequilibrium. This meant that either the daughter products somehow deposited independently or there had been much higher uranium in the past which had leached away. It was not easy to say which. Because of the relatively short half-lives of the uranium daughters the radiometric anomaly must have somehow originated within the last 120 ka.

ARTICLES

The overall natural high radiation field was about the same as of well-known international examples, and probably legally demanded the evacuation of the island according to their Atomic Energy Act, on health grounds! We see later this would have been very unwise.

Contamination?

Because of the possibility of a uranium deposit and health concerns, particularly possible fresh water contamination, an IAEA representative visited the island in 1978 and specifically sampled the subsurface groundwater near sea-level, and some small amounts of trapped rainwater in surface coral. He obtained some anomalous results for uranium, but did not think this necessarily indicated a uranium deposit, and did not find health risks (Smith 1979).

In the meantime an independent prospector, John Barrie of Australia, had become very interested in the possibilities of minable ores, following small scale drilling on the island. In the late '70s, through the offices of a CEO of an Australian commercial firm, John Barrie raised enough money from the public for some larger-scale drilling. The main business of the firm was actually the manufacture of buttons but diversity was even then considered not too outlandish! Drilling was very difficult because of the coral rubble and frequent eroded coral cavities. The drilling continued to 700 m which was well below sea-level, but found no ore deposits, only predominant carbonates: calcite and dolomite. The supposed underlying basalt was not reached. There were some curious trace element excesses, such as vanadium, a possible pathfinder element for uranium. At that point, John Barrie learned that the button CEO had absconded with the entire large funds raised, and no-one could find him thereafter! Drilling of course ceased.

In the '90s DSIR was reorganised. The Soil Bureau disappeared, on the basis that soils of New Zealand were well enough surveyed and it became a related Landcare Research Crown entity. In due course, DSIR Head Office instructed others working on the Niue soil problems that further work was to cease because it was not closely enough connected to New Zealand interests.

Court case and results

In the new century, an Australian mining firm Yamarna became interested in the mining potential of Niue, and this investigation created much public interest and a high share price. They reanalysed some of the samples of Mr Barrie, and fresh surface ones, but finally decided the results were not compelling enough to proceed further. Specifically they could not confirm some interesting previous commercial analyses which in retrospect had been probably too close to detection limits. When the company share price collapsed on the announcement of their withdrawal, the regulatory authorities in Australia decided this was a scam and that there had never been sufficient basis for an exploration. They proposed fines, potentially closing down the company. The defence legal team called together various scientists from Australia, New Zealand and the USA, who argued in submissions that there had been real geological interest and investigation was justified. Eventually the issue was settled out of court in 2008, with each side paying its own costs, which for the defence was about $1M.

Within a couple of years a few members of the defence team, at their own expense, were able to visit Niue and resample soils and water. The Premier of Niue had some of this water on his property, but the research team had difficulty finding the particular small cave, so he was happy to interrupt his cabinet meeting and show them personally. The team could not confirm with more modern methods the water analyses of the IAEA, and concluded there had been analytical problems which was rather surprising.

The previous excellent radiochemical methods were out of reach financially but it became apparent that gamma-ray spectrometry had advanced enough that it could loosely but cheaply confirm the previous radiochemical results.

When a rock is a soil

At this time, a type of black rock (actually deep brown) known in rare localities in Niue near sea-level (Fig. 1) turned out to contain typical soil rootholes and was typical Niue soil cemented with the less common mineral hydrotalcite and/or analogous minerals. This contradicted speculation in the literature for example, that it was palagonite. The hydrotalcite had not been detected in XRD studies of other Niue samples.

Scientists on the defence team thought proper funding and drilling was still worthwhile. They were able to raise funds of a few million $A, subject to obtaining sole rights of negotiation for exploitation, but this ran into procedural difficulties and collapsed.

About 2010, in the course of a ship cruise near New Caledonia, there was a schedule change due to political instability and two members of the defence team were able to spend a day at the island of Lifou, another raised atoll in the Loyalty Islands; this was an unexpected opportunity not previously financially possible, and several soil samples were collected and analysed. The gamma-ray results showed the same nuclide anomalous

Fig. 1. "Black Rock" SE of Vaiea, Niue, 19°08.903'N 169°53.349'E

pattern as for Niue; daughter products were present in excess compared with the parent uranium, which itself was 3-10 times higher than expected for a basaltic laterite. This was obviously similar to Niue and could be one of the islands the Soil Bureau scientist previously mentioned.

Current thinking

Slowly there became available in the literature, accounts of other raised atolls with various similar soil anomalies, particularly Renell and Bellona in the Solomons, Bellona being the subject of a rather large Danish project (Borggaard et al. 2012). These soils have raised uranium contents, claimed to be 480 $mg.kg^{-1}$ and 30-178 $mg.kg^{-1}$ respectively (nearly ore grade!) and some element anomalies of other kinds, but it is not clear whether the radionuclide anomalies are similar to Niue.

Some other soil data diagnostic tools became available from the literature. The ratio Fe/Al is indicative of pre-weathering source material, and shows that the main elements in Niue soils were consistent with ratios in pumice from undersea eruptions in the Tonga Trench, a type of origin also invoked by French researchers for Lifou soils. This means the soils may have partly formed through intense weathering of beached pumice rafts. Further consideration of aerial deposition from volcanoes showed that route was less likely. Use of the Fe/Al ratio also showed that upper eroded calcite/dolomite layers of Niue contributed some content to its soils.

Another technique relied on one of the several elemental measures of weathering in soils. The least weathered soils had the most uranium and there was later leaching of uranium, as expected for this normally mobile element. Extrapolation back in time suggested, like the radioactive equilibrium studies, that the original content approached economic grade – some hundreds of $mg.kg^{-1}$. The Yamarna company had not been scatter-brained when it had proposed investigation.

The least weathered samples contain uranium in equilibrium with its daughters, a state very unlikely to arise through hypothetical independent deposition of the daughters, rather it was subsequent leaching of uranium which had created the radioactive disequilibria.

How could a mobile element like uranium accumulate? It seems that the well known geochemistry of uranium is important – either leached from other carbonate layers or accumulated from seawater, it encountered the known reducing conditions and organic content inside soils and was trapped, a situation occurring in many other settings world-wide. Historic excessive reduced iron in Niue groundwaters possibly enhanced the trapping. The uranium then accumulated daughter products by radioactive decay, but when oxidising conditions returned as the atoll rose, uranium leached away leaving the almost immobile daughters.

It looks therefore that traditional geochemical prospecting failed in this case. The usual principle is that a buried ore deposit increases amounts of ore elements in the overlying soil. The soils of Niue accumulated the uranium, but this did not indicate a nearby deeper ore deposit. It was not economic to mine the soils themselves because they averaged only 25 cm thick island-wide and there are much better uranium sources elsewhere.

No-one knows whether conditions might be conducive to ore deposition even deeper than the 700m drilling. There is a process called endothermal upwelling which circulates seawater upwards through the porous coral in atolls, and if it encounters reducing conditions – say near volcanic basalt - it might accumulate a number of elements from seawater including uranium, but how economic would mining be in porous coral 1 km under the sea?

Although under-sea drilling of several guyots world-wide has never encountered significant sulphide mineral deposits, it would not be surprising if someone ultimately finds one in the approximately 40,000 world-wide guyot examples.

The last few paragraphs and perhaps this whole historical survey illustrate another interesting difficulty which may occur in other geochemical settings. Improved understanding has depended on findings combined from many fields over about 50 years but uses several concepts which are probably new or unfamiliar to at least some readers. There may be too much new material simultaneously drawn from too many areas, to be easily digested.

Health Effects

Effects of radiation on health? Preliminary studies comparing Nlueans and other Pacific Island inhabitants find no differences in cancer occurrence (Foliaki et al. 2011).

There have been detailed health studies in the last 50 years from several areas particularly high in natural radiation; Guarapari in Brazil, Tamil Nadu, India, Yangjiang, China, and radiation in them is usually due to monazite, which contains thorium and uranium. In contrast, on Niue radiation is almost entirely from daughter products of uranium. As on Niue, the doses are several times background levels (Fig. 2) but any health effects are either nil or actually beneficial. Modern research in the world-record high radiation area in Ramsar, Iran, caused by radium and daughter products only, has shown that health of inhabitants is at least as good as other nearby areas, but sometimes significantly better, with fewer DNA breaks. Based on extrapolation of the Hiroshima/Nagasaki data, such radiation levels should have shown negative effects. The reason there are no obvious bad health effects in all these areas seems to be due to induction of higher than normal amounts of DNA repair enzymes which emerge rapidly when first exposed to radiation, hence it is not even necessary to say this is an evolutionary adaptation.

Fig. 2. Luxuriant vegetation on the strongly radioactive soils of Niue Island.

So even if Niueans do not reap a bonanza from an ore deposit, at least their soils may be keeping them healthy! Perhaps another good reason for not mining the soils! ■

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EARTHQUAKE HYDROLOGY AND LIQUEFACTION

(OR 'SOMETIMES RESEARCH, LIKE WINE AND OTHER GOOD THINGS, MATURES OVER TIME')

Simon Cox

As they flew along the newly formed Greendale Fault in September 2010, there were many things that Dr Simon Cox and his GNS Science colleagues could see were clearly awry during the first aerial reconnaissance. But among the offset roads, bent hedgerows and fences, torn and cracked fields, and damaged houses, there was one curiosity that specifically caught Simon's attention: many of the wells now had groundwater flowing out of them where normally it would have been at least 40 metres underground. Having worked on the formation of quartz veins and exploration of gold deposits, which are developed by earthquakes deep in the earth's crust, here was a real-life example of processes he had studied for his PhD and worked on for years, but never actually observed as they happen deep in the earth's crust. Not only that,

An irrigation channel dammed and partially offset by the Greendale Fault. As as seen from an earthquake reconnaissance flight on 4 September 2010. Photo: Richard Jongens/GNS Science.

'Haywire hydrology' as seen from an earthquake reconnaissance flight on 4 September 2010. Offset on the Greendale fault disturbed the flow of Hororata River. Photo: Richard Jongens/GNS Science.

but he was seeing it in full realisation that there would be many recordings of what had happened in monitoring bores all over the Canterbury plains. While there was much to do initially for earthquake recovery, this was a serendipitous opportunity for new science that rarely comes along.

The weird things that seemed to happen to groundwater during the earthquakes also caught the attention of Dr Helen Rutter from Aqualinc, as well as many people from Environment Canterbury and regional councils throughout New Zealand. Emails quickly brought collaborators together and observations were gathered. One of the first things that seemed apparent was that the earthquakes generated a rapid increase in groundwater pressures immediately during the shaking, followed by a drop in the deeper aquifer levels and rise in shallow aquifers immediately after the earthquake. In many places there had been an upwards flow that coincided with emergence of new springs and a pulse of water flowing down the rivers.

The effects were also far-reaching, affecting aquifers throughout New Zealand including over 100 km away in Northland. In a paper[1] in the New Zealand Journal of Geology and Geophysics, which subsequently won the New Zealand Geophysics Prize, Cox and his colleagues postulated that release of artesian groundwater pressure and groundwater flow also played pivotal roles in Christchurch liquefaction.

With support from the Royal Society Marsden Fund and the Natural Hazards Research Platform, a portfolio of 'Earthquake Hydrology' research began to grow. Hydrologic responses in groundwater are a well-documented phenomenon, observed for thousands of years, but of renewed interest due to implications for water supplies, engineering and hazards[2]. But although it appears that permeability is best considered a dynamic variable that can change with stress and strain, exact causal mechanisms are yet to be perfectly understood[3,4]. The density of groundwater and seismic monitoring networks in New Zealand, combined with regular earthquake activity, was a unique opportunity for local research to contribute to internationally. Albeit dominated by observations in permeable young aquifers, events of the 2009 Fiordland, 2010-2011 Canterbury, 2013 Cook Strait and 2016 Kaikoura earthquakes have now been particularly well-documented[1,5-7], and shown to produce changes to groundwater throughout New Zealand lasting locally for many years[8]. Other impactful New Zealand studies, all enabled through collaborations and support of regional councils and the GeoNet facility, include large 'multiple-earthquake at multiple-site' datasets of earthquake-responses that enable causative variables to be controlled and examined[9,10], and the first international attempt to derive probabilistic models of groundwater change given varied levels of shaking[11].

Liquefaction at Kirstens Place as a results of the Mw6.2 Christchurch earthquake, 22 February 2010. Photo: Alun Davies/simplicitywebdesign.co.nz.

With aquifer leakage and compromised aquitards postulated to have somehow been involved in liquefaction[1,6,12], Sjoerd van Ballegooy and other engineers from Tonkin & Taylor became involved in the research. One of the first challenges for understanding liquefaction was to map out exactly what happened within, across, and between the aquifers throughout the earthquake sequence. A collaboration contributed maps of the water table position to help inform the rebuilding of Christchurch[13]. Mapping pressure changes during the earthquakes, the team found groundwater in aquifers beneath Christchurch rose locally in pressure an equivalent of >5m in hydraulic head during the Mw6.2 earthquake (22 February 2011). This added substantially to the +5-10 m 'above ground' pressures that were normally contained by the overlying impermeable aquitard layers. The spatial correlations also appeared very clear as much of the worst liquefaction and surface flooding coincided with the areas that experienced highest groundwater pressures. But 'correlation is not proof of causation' — initial reviews of the work were critical that spatial relationships could have been coincidental because the highest pressures were also where the greatest thickness of liquefaction-prone sandy-silt were found. The science was still premature, and a new approach was needed.

Enlisting further expertise from statistician David Harte, the team began unpicking the relationships between the geotechnical tests carried out by engineers on liquefaction vulnerability, actual observations of liquefaction during the earthquakes, and groundwater pressure changes that had occurred in aquifers about 20-40 m below each site. The first approach analysed at regional-scale relationships between

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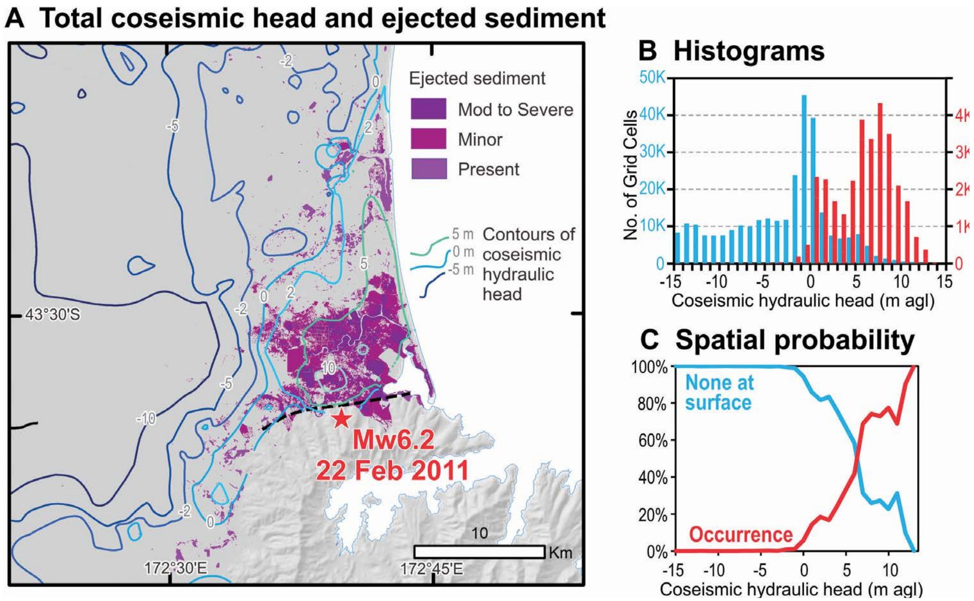

(A) Map of the occurrence of liquefaction as ejected to the surface after the 22 Feb 2011 Mw6.2 earthquake, overlain with coloured contours of total coseismic hydraulic head in aquifers. (B) Histograms of the number of 50 x 50 m grid cells of ejected sediment occurrence (red, left scale) and not observed (blue, right scale) within 1 m intervals of aquifer hydraulic head. (C) Spatial probability distributions for ejected sediment 'occurrence' and 'not observed' derived from the relative proportion of classified grid cells within each 1 m groundwater level in the study area. Reproduction of Figure 4 from Cox et al. (2021).

liquefaction and groundwater, deliberately including areas of the Canterbury Plains to the west of Christchurch to span a wide range of aquifer pressures, potentially resulting in non-causative covariations in the data. The re-analysis looked only within the Christchurch urban area, where there is less variation in aquifer conditions, but lots of geotechnical data. When tests were grouped on the basis of liquefaction vulnerability and soil strength, irrespective of location, places where 'minor' and 'moderate-severe' liquefaction occurred during the 22 February 2011 Mw6.2 earthquake had distinctly higher aquifer pressure than sites where liquefaction was not observed. Now with immediate relevance to engineering, a series of manuscripts were written and rewritten for the journal Engineering Geology.

'It was an incredibly frustrating and long road that was bad for morale at the time' says Simon Cox 'but ultimately a process that greatly strengthened the science. Although it took a decade from initial observations, developing the hypothesis then teasing all the details out, it now seems unequivocal leakage of artesian groundwater contributed to near-surface liquefaction-induced ground damage.'

The final paper[14] was published on the 10th anniversary of the Canterbury earthquakes. It argues that leakage and upwards flow artesian aquifers promoted the ejection of liquefied sediment in Christchurch. It showed that hazard assessments need to consider hydrogeological setting and conditions, that from Christchurch may have been one of the worst-case examples ever experienced, and that there is a need to re-evaluate other examples of liquefaction worldwide.■

**The paper can be downloaded for free from https://doi.org/10.1016/j.enggeo.2020.105982, while the associated data archive can be found at http://doi.org/10.5281/zenodo.4391461

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GEOLOGY AND THE CLYDE DAM

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The Clyde Dam on the Clutha River (Fig. 1), which started generating power in 1993, was the last major hydro-electric scheme to be completed in New Zealand. It was a controversial project, with widespread opposition from local residents and environmentalists. Geological advice and assistance before and during construction was provided by members of the New Zealand Geological Survey (later DSIR Geology & Geophysics, then the Institute of Geological & Nuclear Sciences, now GNS Science). As well as the normal engineering geological issues that arise in a project of this size, there were delays because of the fractured nature of the rock at the dam site, the discovery of active faults, and the drainage and remediation of landslides in the reservoir area.

During the 20-year life of the project, from about 1974-1993, there were major conceptual changes in a number of geoscience areas intertwined with political decisions. This article has been prepared as a summary of the geological issues that arose during investigation and construction of the Clyde Dam, based on written records and interviews. It is an interesting case study with lessons that I hope may be useful in considering future projects involving large-scale landscape modification.


Figure 1. View of the Clyde dam, looking upstream along Lake Dunstan. Photo: Scott Barnard (AECOM, Christchurch).

Engineering and political background

After World War 2 there was a nationwide shortage of electricity – for example, residents of Otago had to endure regular power cuts until the Roxburgh dam began to generate power in 1956. The government started an urgent programme of hydro-electric development with a series of dams planned along the Waikato River in the North Island, and a similar programme in the South Island along the upper reaches of the Waitaki River. A skilled workforce was developed, and when one dam was completed they would move on to the next project. The growing demand for electricity overrode environmental concerns. But by the late 1960s there was a change in public opinion when the Manapouri power scheme was being developed to provide electricity for the Tiwai aluminium smelter near Bluff, which would have raised the level of Lake Manapouri. After widespread protests, led by the 'Save Manapouri' campaign, the Kirk Labour government agreed in 1973 that the lake level would not be changed.

As the hydro-electric schemes in the Waitaki catchment were completed, it was planned to build a series of dams along the Clutha River that would include a dam in the Cromwell gorge near Clyde. Preliminary investigations included ground surveys and a number of drillholes (McKellar 1967). A number of options were considered, and in 1975 the Labour government opted for scheme H, a low dam that would minimise the size of the reservoir, with a second low dam further upstream.. After an election later that year, the incoming Muldoon National government decided to proceed with scheme F, a much higher dam that would generate more power but flood established orchards, the railway and road as well as parts of Cromwell. Protests were ignored, and the high dam became part of the government's 'Think Big' policy, with the aim of using surplus power for a second aluminium smelter.

Design and construction of the Clyde Dam was the responsibility of the Ministry of Works and Development (MWD, later Works Consultancy Services Ltd). As had happened in the past, members of New Zealand Geological Survey provided consultancy advice on geological matters and were actively involved in on-site investigations under the supervision of Chief Engineering Geologist Les Oborn, then by Graham Hancox after Les retired. Royden Thomson, (Fig. 2) an experienced engineering geologist who had previously worked on the Manapouri project was appointed site geologist, and moved to Cromwell in 1974. Initially he was told that the project would last two or three years, but it was almost 20 years until he could hand over the dam completion report (Thomson 1993). At different times he was assisted by other site geologists including Jim McLean, Mark Foley, Graham Salt and many visiting geoscientists.

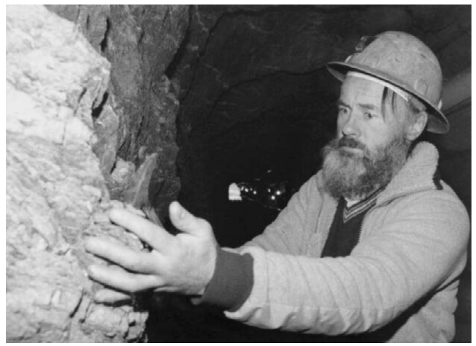
Figure 2. Site geologist Royden Thomsen examining rock exposed in a drainage tunnel at the no 5 Creek slide in August 1989. Dominion Post collection, Alexander Turnbull Library.

Damsite investigations

The geology of central Otago was reasonably well known in the early 1970s as it had been covered by regional 1:250,000 geological mapping only a decade earlier. Ian Turnbull had started more detailed mapping of the Cromwell area which covered the area around the damsite, and provided copies of his field maps as investigations. got underway. The dam site (DG3) was in hard Otago schist at the lower end of the Cromwell gorge, and it was assumed that construction would be straightforward. Some landslides had been identified in the reservoir area (including the Clyde landslide at the dam site), but were not anticipated to cause major problems.

The schist at the dam site was foliated (or layered), and had undergone several phases of deformation. As a consequence there were common shear zones, both parallel to and oblique to foliation, some of which contained layers of low-strength clayey gouge. The foliation itself was almost horizontal or gently dipping. Angled drilling showed the presence a narrow zone of crushed rock at right angles to axis of the dam which subsequently became known as the River Channel Fault. Other smaller faults and joints were mapped by the site geologists as excavation proceeded. Although the rock appeared hard in hand specimen and drill core, once excavated it was more broken and permeable than anticipated.

As a consequence of the defects in the rock, many excavations on varying scales were required in the dam foundations, especially in areas where adversely oriented foliation shears caused concern that part of the dam might slide. Crushed material was excavated out of the River Channel Fault, to be replaced by concrete. Widespread cement grouting was needed to fill voids and avoid leakage around the dam.

In 1982 a contract for construction of the dam was awarded to the Zublin-Williamson consortium. The original contract provided for excavation of 14,000 cubic metres of rock to provide a solid foundation. But eventually the contractors had to dig out almost twenty times that amount of weak rock. The specified concrete pour was 650,000 cubic metres, but the amount poured was 870,000 cubic metres, a third more than specified (Ministerial Review Committee 1990, p 41). One of the final events of the dam construction phase was a long and complicated arbitration case where the contractor claimed for additional costs. Royden Thomson provided expert evidence and underwent lengthy cross examination.

Changing ideas about faulting

From earlier geological mapping, it was realised that the Dunstan Fault separated Otago schist from younger sediments in the Manuherikia depression to the north of the damsite, but the faulting was believed to be ancient. In the early 1960s it was generally believed in the geological community that central Otago was seismically inactive – the 1:250,000 maps of the 1960s did not show a single active fault between the Alpine Fault in the west and the Akatore Fault near Dunedin (which was regarded as an oddity).

Work started on the DG3 site in 1976. From study of aerial photographs Royden Thomson was intrigued by a faint linear feature on a late Quaternary surface north of the dam site close to the Dunstan Fault. He and Ian Turnbull were able to get a trench excavated across the feature which revealed that sediments beneath the surface had been offset by fault movement (Fig 3). It was the first indication of young fault activity in central Otago, with the implication that the region might not be as seismically inactive as previously thought. This was the start of intensive seismotectonic studies of the area around the dam site and further afield in the upper Clutha catchment. The evidence for young faulting was not easy to detect, but was assisted by extensive low-level aerial photography by Lloyd Homer. Royden Thomson, Ian Turnbull and a group of earthquake geologists investigated possible faults, with trenching of selected sites, and this work was integrated with geological mapping. This showed that there were several active traces along the Dunstan Fault (Fig. 4), although all were several kilometres north of the dam site. Despite the huge increase in knowledge of active faulting in the region over the next five years, this was not satisfactorily communicated to the dam design engineers.

In early 1982 the site was visited by Don Deere, an US engineering geologist with experience in dam construction who was engaged by MWD

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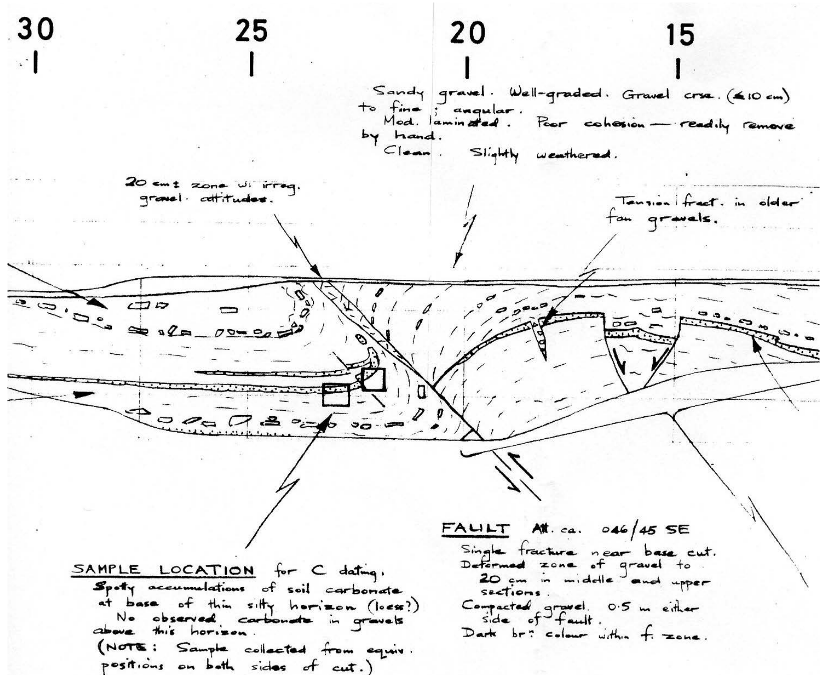

Figure 3. Log of first trench excavated across a suspected fault scarp at Waikerikeri valley in August 1977. Provided by Royden Thomson.

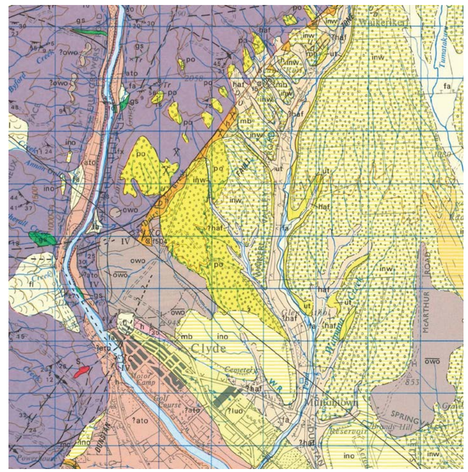

Figure 4. Section of the1:63,360 geological mapcovering the area around the Clyde Dam (Turnbull 1987). This map shows the active fault traces identified during investigations in orangebrown.

to advise on grouting the dam foundations. As well as reviewing the excavated dam site, he raised concerns about the possibility of a future earthquake on the Dunstan Fault that might activate the River Channel Fault. MWD requested an immediate synthesis of the work on active faulting and seismotectonic hazard so that they could evaluate the potential effects on the proposed dam.

The revelation that seismic activity was a possibility coincided with a political crisis. There was a public hearing into the final stages of the water-right hearing for the high dam, and the government was forced to pass amending legislation to allow the project to proceed. There was intense public interest in the issue of future seismic activity, and the Director of the Geological Survey, Pat Suggate, decided that the report sent to MWD must also be publicly released. Realising that he would have to defend the conclusions, he took an active role in the final preparation of the report (Officers of the NZ Geological Survey, 1983). One of the main conclusions was that the Maximum Credible Earthquake likely on the Dunstan Fault was between 7.0 and 7.5, with a return period of 12,500 years. The probability of this occurring in the next 100 years was estimated to be low to very low, but if it did happen there might be some sympathetic movement on the River Channel Fault.

Because of widespread interest and concern within the geoscience community, the report was reviewed by a subcommittee set up by the Geological Society of New Zealand. (R.J. Norris, C.A. Landis and D.H. Bell). While generally supporting the NZGS report, they felt that the estimated return period of surface displacement was too low. Their report and a response from NZGS were published in GSNZ Newsletter 63 (February 1984), pp 14-18.

As a consequence of the information on the seismotectonic hazard, the dam design was modified, including a slip joint to incorporate 1-2 metres of movement on the River Channel Fault. The redesign led to a decrease in generating capacity of the dam from 612 to 464 megawatts (Hatton, Foster & Thomson 1991).

Following the general election in 1984 a Labour government was elected. Although they had opposed the concept of the high dam, construction was too advanced by that time to abandon construction without huge financial penalty, so work continued.

In 1987, as part of major government reorganisation, the ownership of the electricity generation capability, previously controlled by the NZ Electricity Department, was transferred to the Electricity Corporation of New Zealand (ECNZ), a state-owned enterprise. This was to have a major impact on the final stages of the Clyde Dam project. By late 1988 the construction of the dam was nearly complete, and plans were underway to start filling the reservoir.

Landslide problems

The presence of landslides in the Cromwell gorge had long been known and shown on geological maps (Turnbull 1987), but were not believed to pose major problems as they were thought to be ancient and inactive (Fig 5). Objectors to the Clyde Dam, however, pointed to the Vajont Dam in Italy where a landslide in the reservoir in 1963 caused a seiche that overtopped the dam, causing almost 2000 deaths downstream.

Until the early 1980s it was believed that only the Clyde, Cromwell and Cairnmuir slides were of concern, and would need remedial action. All the known landslides were monitored during the construction phase, and it was discovered that some 'dormant' slides in the Cromwell gorge were slowly moving downhill. Exploratory drilling for the new highway led to the discovery of a complex, high-pressure groundwater system near the base of the No 5 Creek slide, and this led on to an extensive drilling programme on other landslides. By 1989, when filling of the reservoir was due to start, an external review recommended further investigation and remediation of the landslides. A strategy was developed for a fast-track stabilisation program, based primarily on the use of tunnels for both investigation and drainage. All known landslides were re-mapped in detail, combined with drilling and tunnelling (Gillon & Hancox 1981). Up to 40 geologists worked on the landslides over a two-year period (below) – it was the largest engineering geological investigation ever undertaken in New Zealand. Gravity drainage was the main method of remediation combined with grouting, buttressing, some pumped drainage and continuous monitoring.

The filling of Lake Dunstan behind the dam commenced in 1992 when the four diversion sluices were closed. The reservoir reached its maximum operating level in September 1993 after a series of intermediate steps to check the continuing stability of the landslides.

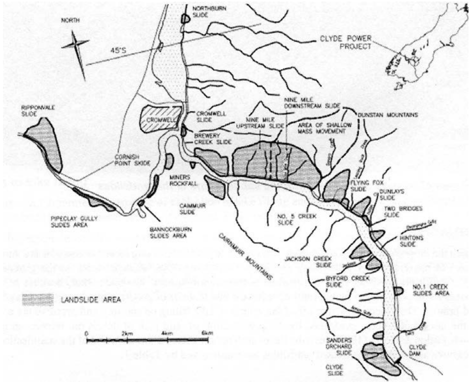

Figure 5. Map showing the main landslide areas surrounding the Cromwell gorge (now Lake Dunstan), from Macfarlane and Silvester (2019).

Monitoring and visual observations over the last 27 years indicate that the landslides are behaving as predicted – they have been classified as either dormant (<2 mm/year) or creeping (2-5 mm/yr) (Macfarlane and Silvester (2019).

Geological lessons from the Clyde dam

Construction of the Clyde Dam took much longer than anticipated, with a final cost more than 45% above the original estimate. It was a controversial project from the start,

Group of engineering geologists working on landslides in the Cromwell gorge during the summer of 1991-92. This probably represents less than half the geologists who worked on the Clydedam project.Back Row: Richard Justice, Richard DeLuca, David Stewart, Jeff Bryant, Royden Thomson, David Barrell, Graeme Halliday, Peter Brooks, Bruce Riddolls, Dean Fergusson, Virginia Cunningham. Front: Tim Coote, Glen Coates, Neil Crampton, Guy Grocott, Dick Beetham, Don Macfarlane, Gary Smith, Peter Wood, Mark McKenzie, Charlie Watts.(Some others who worked on the project include Mark Stirling, Gabrielle Bell, Bill Leask, Peter Manning, Stuart Read, Elizabeth Sowerbutts, Mary-Clare Delahunty, Mark Foley, GrahamHancox, Ian Brown with apologies to anyone omitted from the list).Photographer: Gary Randall, MWD.

with continuous public scrutiny and criticism through the whole construction period. I had a personal taste of this in 1989 when, as Acting Director of the Geological Survey, I had to take part in a press conference explaining that filling of the dam would be delayed for several years due to the need to investigate and remediate landslides in the reservoir area. I was worried that geologists would be blamed, but on the day the reporters were only interested in questioning ECNZ about financial management of the project.

In 1990 the government called for review of the whole Clyde Dam project, and particularly for the reasons for the cost blowout and delays, and I refer readers to this for a frank appraisal of the decision making process (Ministerial Review 1990). But to conclude this short review, I would comment on several geological/geotechnical issues.

One of the major conclusions of the review was that there was a lack of a proper investigation process prior to the start of construction. The DG3 site was selected essentially for political reasons, and had less investigation than other sites preferred by engineers. Only 2.8% of the expenditure by DSIR geoscientific team occurred prior to the final commitment of the project. While the need for a higher level of investigation is unarguable, it is important to realise that some of the issues that arose could not have been reasonably foreseen. For example, while it is tempting to suggest that more investigation would have revealed the presence of active fault traces along the Dunstan Fault and elsewhere, it has to be remembered that there was a widespread belief within the geological community that there were no active faults in central Otago. The first fault traces were not identified by the specialists in the Geological Survey who studied active faults nor by university colleagues, but by site geologist Royden Thomson scanning aerial photographs outside the immediate damsite area. Subsequent work identified more active fault traces in different parts of central Otago.

The discovery of active faults in 1976 led to concentrated investigations over the next five years that included trenching and C14 dating that allowed the history of past fault movements to be worked out, developing a methodology for fault investigation that is still being used today. Strangely, however, this work appears to have had virtually no impact on the design of the dam because of lack of communication between geologists and engineers until visiting US geologist Don Deere raised concerns in 1982.

The Clyde dam site was excavated in the foliated schist that is widespread in Otago. It was assumed that excavation would be straightforward, but in fact there turned out to be widespread shear zones both parallel and oblique to foliation as well as faults and open joints. The combination of these defects in the rock mass meant that the amount of excavation and concrete remediation was much larger than anticipated. While this was difficult to anticipate in advance, it is a lesson for future excavations in schist.

Initially it was assumed that the landslides upstream from the dam site were inactive, but continued monitoring during the life of the project showed that some were creeping downhill very slowly, and investigations along the road line showed locally elevated water pressures. There was a debate about the amount of drainage and remediation needed to stabilise the landslides, but ECNZ elected to take a conservative approach, with continuing monitoring since the dam was filled in 1993.

The above paragraphs are illustrations of the sort of geological problems that arise in a major civil engineering project of this size and complexity. Although more preliminary investigation may have allowed some of them to be minimised, it is realistic to expect that there will always be unanticipated problems in dealing with complex geology.

The concentrated work on landslides involved large groups of engineering geologists, all of whom gained experience on the project. As they dispersed around New Zealand, many have become leaders in the geotechnical profession. There were several important advances as part of the landslide work, including the development of GIS technology for geotechnical work, the project-wide use of 3D modelling, and the development of a computer-based monitoring system, still used 30 years later for all major New Zealand dams.

Bearing in mind the controversy over the construction of the Clyde Dam, it is interesting to realise that it is now accepted as part of the natural environment in central Otago. I recently saw a sign advertising "Lake Dunstan – the jewel of the Clutha", and power companies are proud to advertise that their electricity is 100% renewable. ■

Acknowledgements

In preparing this article, I have consulted many colleagues who worked on different aspects of the Clyde Dam project. In particular I am pleased to thank Kelvin Berryman, Ian Brown, Graeme Hancox, Don Macfarlane, Roydon Thomson and Ian Turnbull for reading draft versions and providing useful comment. I am also very grateful to Kristin Garbett (GNS Science) for her help locating reports and other documents.

Royden Thomson worked as site geologist based at Cromwell through the 20-year life of the project. Many of those interviewed commented on Royden's thorough work, wide knowledge and wise counsel – one person described him as "a quiet voice of sanity when problems arose". This paper is dedicated to him.

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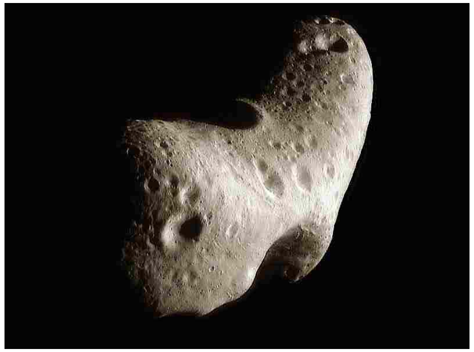
METEORITES OF NEW ZEALAND

Joel L Schiff

Let's get one thing straight. Meteors are those brief flashes in the sky that you often see at night that are actually about the size of a grain of sand and are leftover debris from comets. There are various Māori words for meteor (it depends on the region) such as matakōkiri (the darting ones), and the events were often considered an evil omen. They invariably burn up in the atmosphere so cannot land on Earth. Meteorites on the other hand are fragments of material usually from asteroids (although some have come from the Moon and Mars) that have survived their fiery trip through our atmosphere to land on Earth. As 70% of the Earth's surface is water, most meteorites land in the oceans. Those that survive are at the mercy of the weather on Earth as they have been in the vacuum of space for 4.56 billion years.

There are three main categories of meteorites: stony, iron, and stony-iron. The majority are stony meteorites, and most are of a class known as 'Ordinary Chondrite'. They are material from the rocky component of asteroids, most of whom spend their days wandering around the Sun in the Asteroid Belt between Mars and Jupiter.



Asteroid Eros

Due to the large number of asteroids in the Asteroid Belt, they occasionally collide with one another and some of the material ejected into space can wind up on Earth through a complicated dynamical process taking millions of years.

A depicted asteroid collision

Some asteroids have experienced a heating event early in their early history (as did the Earth), and formed an iron core. When these asteroids are torn asunder, it is possible that some of the core will eventually land on Earth and these are the iron meteorites.

New Zealand represents a very small target on the surface of the Earth. So we are actually very fortunate to have nine meteorites that have fallen here. Probably many more already have but they are either lost in the bush or yet to be discovered. And even if you encountered one would you even bother to investigate an undistinguished black rock on the ground? Maybe now you should— it could be from outer space!

Of course, New Zealand is full of black rocks, namely volcanic basalt but most meteorites contain some iron and so should attract a magnet if you suspend one on a string next to the rock. This is a critical test that you can perform.

However, the naturally occurring mineral, magnetite, will also attract a magnet so the magnet test is just a first step.

Very large meteorites make very large impact scars on the Earth's surface. While none have been found so far in New Zealand, our neighbour Australia has numerous impact craters.

Wolf Creek crater in Western Australia, 1.2 km diameter and 300,000 years old.

But New Zealand does have a record of one of the largest impact events in the history of our planet, namely the Chicxulub impact 65 million years ago that is thought to have led to the extinction of the dinosaurs. There is a layer of soot and clay from the event found in only certain parts of the world, called the 'K/T boundary', and it can be seen in New Zealand.

The K/T boundary at Woodside Creek in Marlborough.

THE NINE(ish) NEW ZEALAND METEORITES

Wairarapa Valley

Classifed as an Ordinary Chondrite H6. Discovered in 1863 at Manaia near the Waingawa River, Masterton. During its time on Earth, it has had a colourful history being lost and found and subject to much misinformation. Main mass at Auckland Observatory.

Wairarapa Valley meteorite showing iron flakes in this cut face view. Courtesy Graham Ensor.

The parent body of this meteorite did not melt and so its free iron remained in the silicate mantle. Courtesy Auckland Observatory.

Makarewa

Approx. 2.3 kg found in a clay bank by two workmen, about 80 cm from the surface, in 1879 at Makarewa (Makariwa) near Invercargill. It is a Chondrite L6 brecciated (i.e. fragments cemented together). An extensive analysis was done in 1894 on two fragments sent to the Keeper of Minerals in the British Museum. Only small samples remain.

Morven

A 7.1kg mass was found on a farm in 1925, 7 km south of the Morven railway station in South Canterbury. Classifed as a veined (dark shock veins form internally from the collision with another asteroid) H4/5 Chondrite. It has a weathered outer crust indicating it was in the soil for a long time.

The main mass of the Morven meteorite which is currently on display at the Otago Museum, Dunedin. Courtesy Otago Museum. ▶

Mokoia

On 26 November 1908, 12:30 pm, following the appearance of a moving cloud and detonations, several stones were seen to fall, and two about 2.3kg each were recovered. Mokoia is a rare primitive type of meteorite called a Carbonaceous Chondrite (CV3.2) that has attracted considerable international research and is the jewel in the NZ meteorite crown. The two main masses are at the Whanganui Museum.

CORRESPONDENCE.

The Mysterious Explosion

TO THE EDITOR.

Sir,—In to-night's "Herald" I saw Mr Irvine's idea of the cause of the rumble at 12.30 p.m. to-day. I take the honour to correct this. I was near No. 1 pole, by the tramway powerhouse, when I happened to look up, and saw a huge white ball fly from the sun in a westerly direction. It had a tail like a meteor and gradually faded off into a long-silver-like line, which remained in the sky for several minutes after the ball disappeared, and then faded away like puffs of smoke. Soon after the ball disappeared I heard an explosion like the boom of a heavy gun. Perhaps astronomers can give us a reason for this.—I am, etc.,

ONE WHO SAW IT.

Aramoho, November 26, 1908.

Left: A slice of the Mokoia carbonaceous chondrite and Above: a news item of the event from 1908.

The two main masses of the Mokoia fall of 1908. Courtesy Whanganui Regional Museum Collection.

View Hill

A single mass of 33.6 kg was found in 1952 at Oxford, Canterbury. It is an iron meteorite classified as a medium octahedrite. Main mass at the Canterbury Museum.

Left: The main mass of the View Hill meteorite Above: A slice showing the characteristic Widmanstätten pattern. Courtesy Canterbury Museum.

Dunganville

A large iron mass, and 68 fragments totalling 54 kg, were found in January 1976 in a dry creek bed by Mr Ted Dowie who was prospecting for gold and nephrite 2km ENE of Dunganville near Greymouth. It is classed as a coarse octahedrite consisting of 6.8% nickel.

One half of the Dunganville meteorite at the Canterbury Museum. Note the very weathered exterior. Courtesy Natural Sciences Image Library.

Kimbolton

A single mass discovered in 1976 weighing 7.5 kg, representing less than half of the original meteorite, was found by Mr R.H. DeRose when he was harrowing a field. Its location was 4 km WSW of Kimbolton, a rural village north of Feilding in the Manawatu District. Classified as a Chondrite (H4). The other piece of the meteorite is probably nearby somewhere.

The recovered portion of the Kimbolton meteorite. Courtesy Noel Munford, Palmerston North Astronomical Society.

Auckland

The most recent NZ meteorite fall occurred at 9:30 a.m. on 12 June 2004 when a grapefruit size meteorite crashed through the roof of Phil and Brenda Archer's home in Ellerslie, Auckland. It is a stony meteorite but has not been analysed ,in order to preserve the integrity of the specimen, but is most likely an Ordinary Chondrite. The meteorite bounced off a couch and hit the ceiling before coming to rest on the floor not far from where the Archer's grandson had been playing minutes earlier. As there is already an 'Ellerslie' meteorite from Queensland, Australia, the name 'Auckland' is more appropriate.

The Auckland meteorite that made its way from the Asteroid Belt to the Archer's lounge in Ellerslie, Auckland. Courtesy Auckland Museum.

As an interesting aside, a single fragment weighing 5.1 g was found in 1960 in the geology collection of the University of Otago, labelled 'Morven' (see above). Subsequent analysis in 1987 showed it to be distinct from Morven and that it was from an asteroid fragment that had been knocked off its parent body some 7.4 million years ago. It has been given the name 'Dunedin'. ■

***For more Kiwi links to meteorites check out 'Mountains to Meteorites' by Brian Mason & Simon Nathan. Take advantage of the GSNZ bookstore winter specials on now.*

"A BUFFET OF SCIENCE!"

Jenny Stein

That's how Victoria University of Wellington PhD student Patty Johnson described GNS Science's Quaternary Techniques Short-Course held at the National Isotopes Centre in Lower Hutt this past April. Over two and a half days attendees were introduced to a range of analytical proxies and techniques for reconstructing the highly variable environmental history of the past 2.58 million years—the time during which we humans evolved as a species, and the time which can perhaps tell us the most about what we can expect from current and future climate and environmental change.

"The whole Quaternary topic is really so relevant for today," says course-coordinator, isotope geochemist and GNS lead scientist, Kevin Faure. Kevin has been organising the Quaternary Techniques Short-Course ever since he was inspired by a similar course that he attended in Australia eighteen years ago.

"I thought, 'why the hell are they doing it? This is what we should do. You know, Quaternary rocks are here in NZ, this is our patch!'"

Together with then-colleague Christine Prior, Kevin organised 'the First Quaternary Techniques Workshop' back in 2002. While the course was well received, he recalls being asked at the time 'Why are you calling it the 'first' QT workshop? Because there'll never be another one!'

Time has proven the sceptics wrong however, with the course having run every year since, except 2020 (thanks COVID-19), and has been steadily gaining in popularity.

"We've got to a point where we've actually had to turn people away," Kevin explains. "Fifty people is too much for us to cope with, but thirty is ideal. We can get them through the labs, it's more manageable, and I think the participants get a lot more out of it."

Visiting the NIC labs is definitely one of the highlights for participants, with many of this year's attendees commenting on the excitement of seeing 'behind the scenes', inside the laboratories that they may either be using themselves, or else submitting

Participants try their hand at sampling appropriate material for radiocarbon analysis.
Image credit: Jenny Stein

Participants getting a briefing before rugging up to enter the ice core storage freezer. Image credit: Jenny Stein

samples to in the future. The mutual benefit of this experience is clear, with many participants gaining a better appreciation of how, no matter how rigorous your analytical technique, the quality of data you get out will always be fundamentally limited by the quality of the sample you submit.

This was particularly well brought home during a practical demonstration inside the Rafter Radiocarbon Laboratory, where attendees learned that one fragment of organic matter is very much NOT like another. Thinking of sending a piece of wood or ball of roots off to get a radiocarbon date for a sedimentary deposit? You may want to think again as that wood might have come from the heart of a long-lived tree, or those roots from modern plants that have infiltrated your sampling horizon. In either of these cases the radiocarbon age determined for the samples may have nothing at all to do with the depositional date of your sediment. Much better to send in a seasonal piece of organic matter, such as a leaf, twig or seed, as such short-lived fragments are far more likely to give you a meaningful depositional date for your sample (as long as they show no signs of having been reworked from earlier sediment...).

Other facilities participants were able to visit included the microfossil preparation lab, drill-core scanning and processing area, one of several on-site mass spectrometers, and many also got to try their hand at using a portable XRF. A much-anticipated highlight was a tour of the ice core facility where, in addition to learning about the range of information that can be determined from the c. 800,000 year long climate record contained within Antarctic ice, participants got to experience the novel sensation of having tiny icicles rapidly forming inside their nose.

In addition to laboratory tours the bulk of the course consisted of presentations from a range of active researchers. This year's programme included introductions to paleo- and environmental magnetism, microfossil analysis, radioactive and stable isotopes, ancient and environmental DNA, lipid biomarkers, tephrochronology, soil stratigraphy and cosmogenic nuclides. Such a broad range of information is particularly relevant to the course's many student attendees, most of whom have either just embarked (or are about to embark) on post-graduate study.

"I think it's really given me a good perspective," said Ruby Haxton, a prospective Masters student at Victoria University of Wellington. "It's opened up an idea of a lot of different fields that perhaps I hadn't considered before." The course was also a chance for GNS personnel based at other sites to come and see what their colleagues at the NIC get up to, and to learn more about the latest in analytical techniques.

"I think science is a multidisciplinary approach," says Estefania Santamaria, a hydrogeologist at GNS Science's Wairakei office. "So, every technique, everything that you are learning—though you think it's not connected to what you're doing, probably you can use it or get some ideas, to continue and get more information."

ARTICLES

This year the course also attracted one or two interested members of the public who were keen to learn more than what they can glean from mainstream media about geoscientific research in New Zealand.

"Even though media is simplified it's not enough. I want to know more!" says Elise Bailey, a scout leader from Wellington who is keen to help her nine-year old become inspired by geoscience. "Even if you don't understand the nitty grit bits down to atoms and split atoms, that's okay, because it puts it all in context."

With something for everyone on offer, it's no wonder the Quaternary Techniques Short-Course continues to be an annual success. Kevin thinks the key lies in the fact that the course deliberately presents information that is not available in formal publications.

"The whole idea is not just to present stuff that people can go read in a manuscript or a book, but it's those little secrets, things that people would never put in a publication…the things you've tried that didn't work. Those are the kinds of things we try to bring to the short course, and also our manuals. The handbook is really full of those little tips and hints and tricks that should be avoided."

In addition to providing a useful roadmap of pros and pitfalls for those about to embark on research of their own, the course is a chance for budding researchers to connect with people who are likely to become their colleagues in years to come.

"One thing they probably don't realise is that the people they are on the course with are the people they're actually going to parallel their careers with, not just in NZ, but anywhere internationally," Kevin explains. "These are people they're probably going to be seeing in 50 years' time when they're old and grey!"

All told, it's amazing what was able to be packed into just two and a half days, and several attendees were left eagerly wanting more (not just of the course but also the delicious catering…).

One or two even suggested the course could be expanded to fill an entire week so that lab visits could be made even more 'hands-on'. Perhaps this is something for Kevin and the team at the National Isotope Centre to consider for future courses, but for now they can rest easy knowing that the 2021 Quaternary Techniques Short-Course has once again helped inspire another cohort of eager researchers. ■

Participants and presenters of the 2021 Quaternary Techniques Short-Course. Image credit: Jocelyn Turnbull

ACCESS TO OAMARU PILLOW LAVA

Bruce W. Hayward

Oamaru pillow lava is indisputably the most photogenic example of pillow lava in New Zealand, because of the light-coloured calcareous sediment that fills the spaces between the lava lobes contrasting with the dark grey of the pillows (Figs. 1-2). Until recently, it was also one of the most easily accessible pillow lava localities**.** Prior to 2010, access was via a 10 minute walk along Graves Walkway from the end of Waterfront Rd, Oamaru (Fig. 3).

For the past 20 or so years, access from the end of the road to the walkway had been inconvenient because of the spreading development of the blue penguin colony and viewing grandstands, that have become a major tourist attraction to keep tourists overnight in Oamaru. The penguins arrive home around dusk after a day fishing out at sea and jump up the concrete ramp and across the route of the track to their artificial burrows at the foot of the cliffs. This led to a closing of the walkway from before 5 pm until the following morning.

Graves walkway had been dug into the coastal cliff about 5-10 m above high tide

Figure 1. Oamaru Pillow Lava: 'The most photogenic pillow lava in New Zealand".

Figure 2. Oamaru Pillow Lava

and provided access from Oamaru township around the rocks to the gravel beaches on the end of Cape Wanbrow. There had been no upkeep work on the walkway by DoC since 2010. Reportedly storm erosion made it impassable in 2013 but it was repaired (possibly by locals) and is still intact but formerly closed with a wooden fence across it. I do not recommend trying to use it except in an emergency as it is now partly buried by loess scree that has come down from the slopes above.

When two Dunedin geoscientists heard that I was planning to visit the pillow lavas this year, I was told by one that there was no access now because the track was closed, and by the other that you could get down to it by coming down a track from the top of Cape Wanbrow, but that was now getting dangerous. Undeterred, I visited the pillow lavas on two consecutive low tides in March this year and can report that access is still publicly open and safe if you know where to go and when.

Option 1.
From Lookout Point carpark at the end of Tamar St. via Cape Wanbrow mountain bike and walking tracks. Suitable for groups of all ages. From half tide and lower (1.4 m and lower) it is possible to see and touch pillows in the base of the cliffs at Second Beach where the track comes down to the gravel beach (Fig. 4). For 1-2 hours either side of low tide (1m and lower) it is possible to move around the base of the cliffs to the north to the small Boatman's Harbour and see and touch the whole pillow lava flow in the base of the cliff and out into the shore platform.

Figure 3. Map of the northeast corner of Cape Wanbrow on the southeast fringe of Oamaru showing the two access options.

Figure 4. Pillow lava adjacent to where Cape Wanbrow Track reaches Second Beach, at mid tide.

Option 2.
From the end of Waterfront Rd, around intertidal rocks at low tide (when tide is 0.9 m and lower). Suitable for small groups of physically competent people. You can only visit when the gate through the penguin viewing area to the breakwater and beyond is open (9AM-5 PM). You may have to negotiate your way past a few basking fur seals, especially around the penguins' concrete ramp. The route around the rocks at the foot of the cliffs is not terribly difficult for field geologists and involves no climbing, so long as the tide is low enough and there is no storm waves. Time from carpark to pillow lava in Boatman's Harbour (Fig. 5) is about 15 minutes.

Enjoy. ■

Figure 5. At low tide access is possible on the shore platform seaward of the cliffs containing the beautiful pillows at Boatman's Harbour. This section of the Graves Track has been rehabilitated and incorporated into the Cape Wanbrow Track from the Lookout.

WHITECLIFFS BOULDERS

A PLACE TO VISIT IN THE RANGITIKEI

Bruce W. Hayward

A little-visited tourist attraction on a private farm on the banks of the Rangitikei Gorge, Mangaweka, is a cluster of a hundred or so 1-2 m diameter spherical concretions that are marketed as the Whitecliffs Boulders. The carpark is several kms along a narrow gravel road and down an even narrower farm road. From there it is an easy walk down 100 m (in elevation) farm track to a patch of forest just above the Rangitikei River.

The Whitecliffs Boulders occur in the patch of forest on the low terrace above the right side of the Rangitikei River (right of centre).

The trip back up to the hill to the carpark is a bit of a grunt especially on a hot summer's day. En-route there are fabulous views of the incised meanders of the Rangitikei Gorge, high mudstone and fine sandstone cliffs (Rangitikei Group) and the famous river terraces.

The spherical concretions are more numerous and mostly slightly larger than their cousins in the South Island - the Moeraki Boulders. Like most concretions exposed at the surface, some are still intact but quite a few have split in two. They are all located under a forest canopy surrounded by grazed farmland and towering river cliffs – a picturesque setting beside the river.

The presence of this tightly grouped cluster of large concretions sitting on the surface of a Holocene degradational terrace between the river and the 80 m-high cliffs is puzzling. The terrace is on the inside of an abandoned, cut-off river meander. Apart from one or two isolated concretions on the terrace within 100 m of the cluster, there are no other similar large spherical concretions to be seen in the gravel bed of the river, on any of the other nearby river terraces nor to be seen in any of the surrounding massive mudstone and fine sandstone cliffs. So where did the concretions come from and how did they get here?

The explanatory sign at the boulders states: "The Whitecliffs boulders are called concretions and were formed within the rocks where they are found." Massive Early Pleistocene mudstone and fine sandstone (2-2.6 million years old) form the entire thickness of the cliffs on both sides of the river in this vicinity (lower Rangitikei Gorge; Naish and Kamp, 1995). High up there are several thin concretionary sandy horizons but nowhere is there sign of any large spherical concretions. Thus there is no direct support for the inference that the concretions have been eroded out of any of the overlying 80 m of mudstone and fine sandstone that can be seen. If the concretions were transported down the river in huge flood events, however, why would they all be concentrated on one portion of river terrace, about 5 m above the present riverbed, and not be found on any of the other low terraces all along this section of the river?

The sign continues: "Rivers carried sediment from eroding land out to sea. The mud part of these sediments settled out into about 150-200 metres of water. Shells and trees were also carried out to sea and were trapped in the sediment. The mud was full of water and as new sediments was deposited on top of the mud, the water was squeezed out. The water contained dissolved chemicals that dropped out of solution and formed a cement around what was left of the buried shells or plant material." I could not see any wood in any of the cliffs nor see wood or shell in the centre of any of the split concretions, but it is well established that many concretions do in fact grow around fossil material. A number of the split Whitecliffs boulders have eroded out centres, 10-40 cm in diameter, that suggest that whatever the concretions grew around is considerably softer than the concretions. Some of the partly eroded centres can be seen to be composed of uncemented mudstone.

Another observation that seems to hold a clue to the origins of these concretions is that all are clearly made of cemented, laminated fine-medium sandstone and not massive mudstone or fine sandstone. The bedding is clearly visible in each and some concretions have split along a bedding plane. This leads me to two hypotheses:

1. the concretions grew within a lens of laminated fine-medium sandstone – possibly an isolated submarine channel deposit within the lower half of the Rangitikei Group. This is far more plausible than growing within mudstone as the carbonate cement would be more easily transported to the growing concretions in groundwater passing through permeable sandstone than through the less permeable/impermeable mudstone;

2. the centres of the concretions are rip-up clasts of mudstone within the sandstone lens and these are most easily explained as having being eroded from the side of a submarine channel.

Some of the Whitecliffs Boulder spherical concretions.

As to where the concretions have been eroded from, there are two competing hypotheses:

A. they have eroded out of a channel associated with a sandstone layer at some unknown stratigraphic level nearly directly above. The tight cluster could indicate that the source was not far above, but there is no suggestion of a sandy channel in the 80 m thickness immediately above as seen in the surrounding cliffs. Could the source be even higher than the cliffs? There is at least 400 m thickness that has been eroded off above the cliffs (Naish and Kamp 1995). I envisage some concretions beyond the edge of the cluster would have been carried away at various times by the Rangitikei River when in huge flood.

or

B. they have eroded out of the known channel at the base of the Rangitikei Group that contains a conglomerate of mudstone clasts in a sandstone matrix and outcrops 2-3 km upstream in the banks of the Rangitikei River and its tributary (Naish and Kamp, 1995). I am sure the river could move these huge concretions within its bed during large floods but would be unlikely to move them up on to the flood plain terraces. If this is correct then the location where the boulders now sit was probably the erosional main bed of the river channel a few hundred years ago. These concretions could have accumulated here on the outside of the bend and been left stranded as the river channel moved inwards (north) and incised deeper. Erosion of the sandstone layer bearing the concretions may have lasted a limited period of time and now be above river level. Many more concretions were undoubtedly eroded out but all except those at Whitecliffs have subsequently been transported away or worn away by the river. The fact that the concretions sit on the surface of the terrace and do not appear to be surrounded by or part buried by smaller river gravel favours option A. The fact that a possible source channel with large mudstone clasts is known a short distance upstream favours option B.■

A split 2.5 m diameter spherical concretion with a weathered out hollow in the centre which was occupied by a soft mudstone cobble that the concretion grew around

Reference:

Naish, T., and Kamp, P.J.J. 1995. Pliocene-Pleistocene marine cyclothems, Wanganui Basin, New Zealand: a lithostratigraphic framework. *New Zealand Journal of Geology and Geophysics 38*: 223-243

2020 FIELD TRIPS

BY AUCKLAND GEOLOGY CLUB/BRANCH OF GSNZ

Bruce W Hayward

In spite of the Covid-related lockdown disruptions endured by Auckland in 2020, the Auckland Geology Club and Branch of GSNZ managed to still get out and about and see some of country's exciting geology field sites. The biggest casualty was our planned April 2020 field trip to Tasmania which has been postponed indefinitely.

We managed to have ten field trips during the year compared with our usual 12-14 and, once again, none of our trips were cancelled because of bad weather. These trips were:

- **Clarks Beach-Waiuku,** Pleistocene geology (Feb, leader Hugh Grenfell, 15 attendees);
- **Cudlip Pt, Mahurangi Regional Park,** Waitemata Group (Mar, Bruce Hayward, 16);
- **Campbells Bay,** Waitemata Group (Jun, Bruce Hayward, 37);
- **Swanson pot holes in streams** (Jul, Michael Coote and Kent Xie, 24);
- **Karekare to Pararaha,** Waitakere Volcano (Aug, Bruce Hayward, 28);
- **South Auckland Volcanic field,** northern parts and Karaka Volcano (Oct, Wendy Goad, 12);
- **Tasman District** geohighlights (8 days, Nov, Bruce Hayward, 24);
- **Mangere Treatment Plant,** Pliocene fossil dig (Nov, Bruce Hayward, 23);
- **Browns Bay to Murrays Bay,** Waitemata Group (Nov, Bruce Hayward, 15);
- **Tahuna Torea,** Holocene geomorphology, Christmas BBQ (Dec, Bruce Hayward, 23).

The average attendance on all field trips was 21, up on last year's average of 17. Escaping cabin fever might be the explanation.

As in recent years we have also offered geology walks for the public during the Auckland Heritage Festival in Sept-Oct.

In 2020 these were:

- **South Auckland Volcanoes** (led by Wendy Goad, 20 attendees);
- **Muriwai pillow lavas** (Bruce Hayward, 10, wet day);
- **Stanmore Bay Waitemata recumbent fold** (Bruce Hayward, 46);
- **Three Kings volcano** (Bruce Hayward, 51);
- **Maungarei/Mt Wellington volcano** (Bruce Hayward, 65).

We are all hoping Covid does not disrupt our 2021 field trip programme.■

Fossil tree stumps in-situ, killed and buried by 1 million year old Putaka Ignimbrite, Waiuku Estuary.

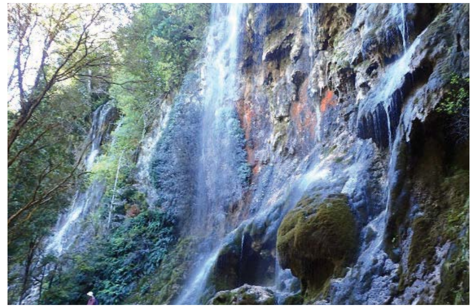
Holocene sand-dune-dammed swamp, Pararaha, Waitakere Ranges.

Determining how these potholes were formed in Swanson Stream, west Auckland.

Examining slump structures in the Waitemata Sandstone section, Campbells Bay.

TRIPS & TRAILS

Visit to Nelson Boulder Bank and lighthouse.



Whispering Falls, east Nelson, flows over part of New Zealand's largest travertine deposit.

Toasted marshmallows and billy tea at Natural Flames gas seep, Murchison.

Sinkhole in marble near summit of Mt Arthur, NW Nelson.

GEOID HIGHLIGHTS

GEOEDUCATION, OUTREACH, AND INTERNATIONAL DEVELOPMENT

Michael Petterson: GeOID convenor

The main highlight for GeOID was the re-initiation of Geo-Education within GSNZ with the addition of Outreach and International Development to offer a 'home' for a wide range of activities spanning professional academics and amateur enthusiasts.

The new SIG has produced a number of newsletters which have highlighted aspects of Geoscience and the Sustainable Development Goals, reviews on Geo-education approaches in schools, colleges and universities, and the state of Geo-education within the school system in terms of student numbers and scope.

One particularly big highlight was the special SIG session at GSNZ Conference 2020 which attracted a wide range of speakers and interest, focusing on geoscience and development, the history of geoscience education in schools, geo-education and distance learning in the COVID era, and general public outreach, communication and awareness.

The SIG meeting was very well attended and the resounding message of the meeting was for the group to focus on geoscience at school level in New Zealand. This has been taken on board with resolutions submitted to GSNZ for this area, and the strong possibility of an imminent symposium on this subject. ■

Editor's note: Symposium details have been released since this summary was submitted. See p65.

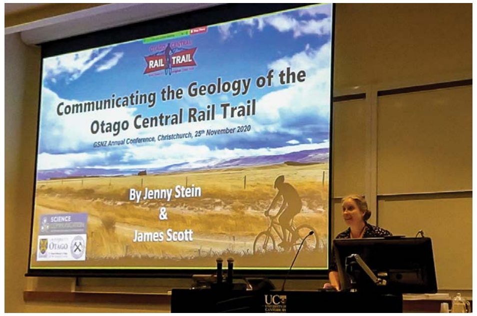


Photo credit: Janis Russell

Jenny Stein presents her work, on communicating the Geology of the Otago Central Rail Trail to visitors, at the GSNZ conference 2020.

Photo credit: Jenny Stein

Investigating a large concretion in a cutting near the highest point of the Otago Central Rail Trail between Idaburn and Wedderburn, Central Otago.

Photo credit: Jenny Stein

Looking southeast across the Manuherikia Bridge between Olrig and Chatto Creek on the Otago Central Rail Trail, to where schist tors of the Waipounamu Erosion Surface are exposed on the foothills of the Raggedy Range, Central Otago. ▶

PETROLEUM IN 2021

UPDATE

Mac Beggs: Petroleum convenor

Newsletter 32 (November 2020) contained a reasonably comprehensive review of New Zealand's petroleum industry and its outlook. The following is intended as a concise update.

2021 is not playing out very favourably for exploration with a low level of investment and activity; or indeed for production of oil and gas in New Zealand.

Offshore

As expected, all offshore exploration permits in basins other than Taranaki have been relinquished (five were still in force last November), and no further exploration can be permitted there due to the ban introduced in 2018 and incorporated into the Crown Minerals Act in 2019. Two exploration permits in offshore Taranaki have also been relinquished, leaving seven in force.

Decommissioning of the Tui oil facilities is being undertaken at the Crown's expense following the liquidation of its last operator, Tamarind Offshore. The handover of the Maari oil field from OMV to Jadestone Energy has yet to be completed.

OMV has maintained significant activity across its other offshore Taranaki projects.
A programme of 6-9 wells from the Maui A platform infilling the crestal part of the structure got underway last October, contributing to gas production from December, and was expected to take 12-18 months. OMV has announced the contracting of a "gorilla-class" jack-up drilling rig for development work at Maui B, subject to a pending final investment decision. This rig is due to arrive in Taranaki waters late this year.

Besides the Maui B work, this rig may also be deployed for an exploration well within the Maui permit (Maui-8, deferred from last year's offshore drilling campaign with the advent of the pandemic lockdown), appraisal of the Toutouwai discovery to the north of Tui, and potentially other exploration wells and/or remedial work in the Pohokura field.

Pohokura has experienced largely unexpected production declines over recent months, with significant consequences in New Zealand's energy systems as a whole, summarised below.

OMV and its joint venturers hold two other exploration permits in offshore Taranaki in addition to that containing Toutouwai. Long time participant in these joint ventures (including the Toutouwai permit), Mitsui, is rumoured to have withdrawn.

The third offshore Taranaki gas field, Kupe (operated by Beach Energy), has continued to produce from the wells completed over a decade ago, with additional compression being implemented this year to extend that "plateau" production rate into 2024.

Exploration permits adjacent to the east and south of Kupe field are operated by WestSide (who hold the adjacent onshore petroleum mining permits) and Todd respectively. Todd also hold two exploration permits in the in the northern part of the basin – one containing the undeveloped Karewa gas field and the other to its north.

Onshore

A handful of onshore Taranaki exploration permits have undergone full or partial relinquishment. The government is due to make a deferred announcement of the outcome of "Block Offer 2019" before 1 July 2021. The previous (2018) Block Offer resulted in just one new permit, to Todd Energy, covering 105 km2 to the south of their Mangahewa and McKee mining permits.

Todd Energy has drilled two new development wells in the Mangahewa field, which as well as their Kapuni field and Greymouth's Turangi field contain substantial partially developed gas and condensate reserves and contingent resources.

Downstream

Gas consumption in New Zealand has reportedly fallen in tandem with curtailed production from Pohokura (which has been the largest single producing field for many years – 29% in 2020). Recently Energy News reported that in late May, the field produced barely 100 TJ of gas in a day compared to 133 TJ on January 1, and over 200 TJ on 14 May 2020. The decline is reportedly due to unexpectedly poor well performance.

Reduced gas output has coincided with lower than usual inflows to hydro catchments, and less wind than usual. Our electricity demand is being partly curtailed by some large industrial users and otherwise met through the use of coal at the Huntly power station. Its turbines could be running on natural gas (or coal from the underlying field or elsewhere in the Waikato for that matter) – but instead, coal is being imported from Indonesia and transported to Huntly by truck from Tauranga and Auckland ports.

On paper, there are reserves in developed Taranaki fields (the three largest onshore fields produced 35% of the national total in 2020) sufficient to have forestalled the less energy efficient and more emission-intensive use of coal at Huntly. The situation seems to reveal that in addition to the issues with Pohokura, and allowing for contractual dedication of a substantial proportion of production for petrochemicals (methanol, urea), onshore Taranaki fields are insufficiently developed to have risen to the occasion.

Furthermore the circumstances suggest that the business case for the relatively aggressive development investment which would be required to cover peak seasonal demand (sometimes, as lately, compounded by outages elsewhere in the energy system) may be insufficient.

Recently both the Minister of Energy and Resources and the Climate Change Commission may have started to recognise the complexities in transitioning away from petroleum while maintaining acceptable cost and reliability for our energy system. Such complexities need to be factored in to policy settings which have started to unhelpfully throttle what could still be a more efficient and lower emitting system than we have right now.

To conclude – the petroleum industry is not yet dead, from either its natural aging or from the political blows it has taken. But neither is it proving well enough to do all of the work expected of it. ■

CALL FOR AWARD NOMINATIONS

AND APPLICATIONS FOR THE 2021 GSNZ ANNUAL AWARDS

The awards on offer this year are listed below. Please note, this year the Hornibrook Award (offered in alternate years) and the S.H. Wilson Medal for Geochemistry (offered once every four years) are open for nominations.

Please email your nominations/applications to the Awards Subcommittee Convenor, Kat Holt, at vp@gsnz.org.nz by the **1st of September 2021**. For more details on individual awards and to download nomination templates please visit http://gsnz.org.nz/awards

PREMIER GEOSCIENCE-WIDE AWARDS:

Hochstetter Lecturer

For a geoscientist with excellent public speaking skills to present new research to all branches of GSNZ. We welcome nominations of ALL members of the geoscience community for this award, from ECRs, through to senior geoscientists.

McKay Hammer

For the author(s) of the most meritorious geoscience paper(s) from the last 3 years (2018-2020).

GSNZ Honorary Member

Nominations are called for to recognise outstanding lifetime contributions to geoscience in New Zealand.

Hayward Geocommunication Award

Awarded to a NZ-based geoscientist or geoscientists for the most meritorious contribution to geocommunication in the previous 3 calendar years (2018-2020).

YOUNG RESEARCHER/STUDENT AWARDS:

Hornibrook Award

For a postgraduate student undertaking a research project involving methods of stratigraphic correlation and of relevance to NZ and/or the southwest Pacific.

Jim Ansell Geophysics Scholarship

Post-graduate scholarship for NZ's top up-and-coming geophysicist.

John Beavan Geodetic Fieldwork Grant

Support for students involved with geodetic research to undertake or participate in associated fieldwork.

Wellman Research Award

A contribution of approximately $3750 towards research in New Zealand. Contribution can cover field, travel, analytical expenses, etc (more details on website).

Werner F. Giggenbach Prize for Geochemistry

For the most outstanding geochemistry publication in 2020 by a NZ-based young researcher.

SPECIAL AWARDS:

S.H. Wilson Prize

Awarded in recognition of a lifetime of service in New Zealand Geochemistry.

New Zealand Geophysics Prize

For the most meritorious publication in NZ geophysics in the current and last 2 years (2019-2021).

Harold Wellman Prize

Awarded for a recent discovery of important fossil material within New Zealand.

Kingma Award

Awarded to the most outstanding Earth science technician in New Zealand.

Alan Mason Historical Studies Fund

Up to $500 awarded to assist research on the history of Earth science in New Zealand

AWARDS FAQ:

Learn more about who is eligible and how to apply for the GSNZ Awards.

Who can apply? Are the awards just for students or high-flying senior scientists?

Our awards are open to all members of the Society. Yes, we do have awards that are just for students, and a couple are directed at those with a long history in the Geosciences. But the remainder are available to anyone who fits the criteria for a given award. We would welcome more nominations for/from Early Career Researchers for awards such as the Hochstetter Lecturer, New Zealand Geophysics Prize, Hayward Geocommunication Award, and McKay Hammer, the majority of which may have anecdotally been regarded as the territory of more established researchers.

Can I apply for these awards myself, or do I have to be nominated by someone else?

This depends on the award. For some awards (e.g. most of the student awards and the Alan Mason Historical studies fund), it is generally expected that the recipient will also be the applicant. For the majority of the other awards, it has traditionally been that recipients are nominated by others. However, this does not mean that you cannot arrange for yourself to be nominated if you would like to be considered for one of the awards. The Awards Subcommittee would welcome self-nominations for all other awards, with the exception of the GSNZ Honorary member and S.H. Wilson Prize. Depending on the award, you may still need to find nominators to support your application, but you can be responsible for completing and submitting the applications yourself.

Is it a lot of work to apply?

Generally no. Some awards require more input than others. Most of the work in any given award is writing the justification to explain why the applicant/nominee is a worthwhile recipient. To get an idea of how much work is involved for a particular award, go to http://gsnz.org.nz/awards and download the award template for that award.

Who judges the Awards?

The majority of the awards are judged by the Awards Subcommittee, which is chaired by the current Vice President of the Society. The Subcommittee usually consists of the Chair plus at least 4 or 5 other geoscientists selected by the Chair, some of which may be members of the National Committee. The makeup of the subcommittee changes each year. The Chair aims to ensure that the Subcommittee contains members from a range of institutions (Universities and CRIs) and disciplines. Some awards (Wellman Research Award, Wellman Prize, Werner F Giggenbach Medal, S.H Wilson Prize) have rules which state the decision lies with other parties. However in practice, the Awards Subcommittee will generally make a recommendation to these other parties, who can then ratify it.

If I submit an application or nomination this year and it isn't successful, can I resubmit it again the following year?

Yes! We do recommend checking with the Chair of the Awards Subcommittee first. But as long as the award is offered again in the subsequent year and the application still complies with the respective rules for the award (e.g. publications relating to a particular timeframe, etc.) then we do encourage resubmissions.

What are the chances of success?

Lately, pretty good! In recent years, the majority of our awards have, on average, received fewer than five nominations in a given year. We'd like to see this change though, so please get writing and nominate yourself or your colleagues & students for these awards which recognise excellence in our community! ■

James Scott and Kat Holt present the Hayward Geocommunication award, at the 2020 GSNZ conference dinner, to the Hikurangi Subduction Margin Project Team. Photo credit: Janis Russell.

James Scott announces the 2020 Hochstetter Lecturers— Darren Ngaru King and Dan Hikuroa who accepted their award by videolink, at the GSNZ Conference dinner, in Christchurch. Photo credit: Janis Russell.

MIRIAM DELL AWARD 2021

RECOGNISING EXCELLENCE IN MENTORING WOMEN IN SCIENCE

Do you have a magnificent mentor? Why not nominate them for this Award from the Association for Women In Science.

Nominations are still open for **The Miriam Dell Award for Excellence in Science Mentoring.**

Guidelines and nomination forms are available at https://tinyurl.com/Mirdell

Nominations close 31st July

AWIS also offers two other awards:

— The AWIS Stem award which provides financial support for women studying STEM subjects.

— Gatehouse Travel Awards are available to women working in science or studying science (at tertiary level or above) to attend an event that offers career development opportunities, These awards are for indirect costs eg childcare at a conference.

AWIS provides support and advocacy, in three key areas, to better the position of women in the sciences in New Zealand:

—Addressing bias, both conscious and unconscious
—Developing careers
—Ensuring work-life balance.

This is achieved by:
—Making submissions to government on relevant policies
—Sharing data and research related to women in the sciences
—Hosting networking and learning events

For more on the work of AWIS vist their website: www.awis.org.nz

MOUNTAIN MYSTERY?

A READER INVITES SUGGESTIONS FOR LANDFORM FORMATION

John Rhodes visited the North King area of the Tararua Ranges last February and came across this strange landform. He invites readers to speculate as to its origin. ■

View of the landform (right of centre) from North King, Tararua Ranges. Photo credit: John Rhodes

Paul McCredie happened to be in the vicinity a few days earlier and captured this image from below with his drone. The landform in question is on the skyline just right of centre.

GEOSCIENCE QUIZ 34

SHARE THE CREDIT

by Aenigmatite

Science has many examples of multiple independent discoveries. So, sometimes laws, rules and relationships get named after more than one person. In the following list, can you match the names with their fields of discovery?

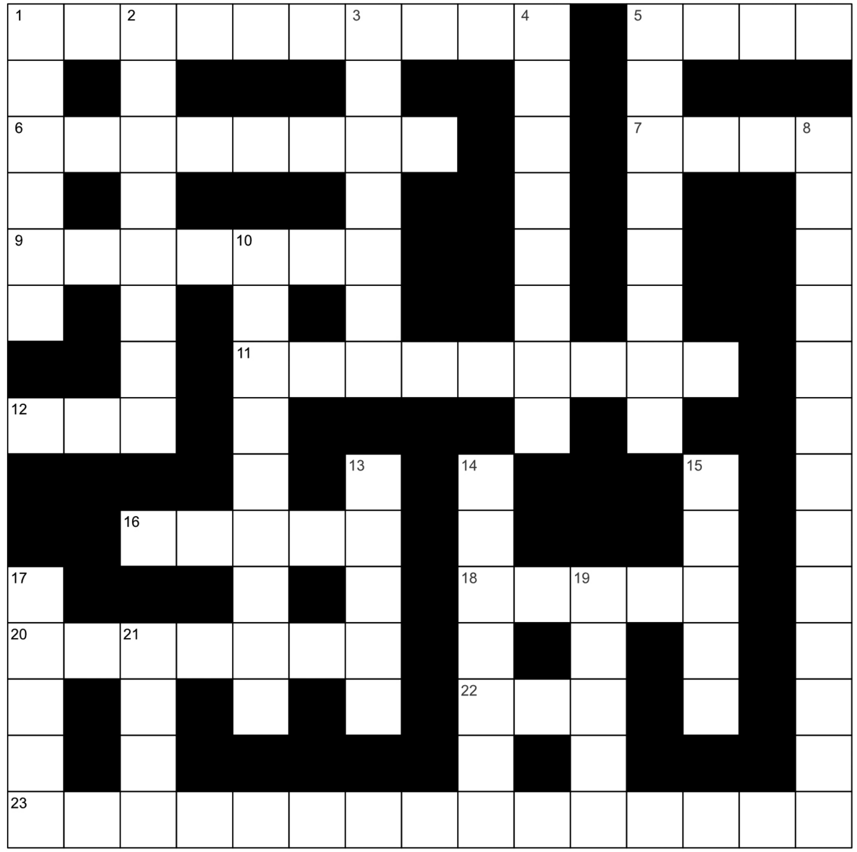
1. Biot-Savart
2. Dansgaard–Oeschger
3. Dunning-Kruger
4. Gibbs-Helmholtz
5. Gutenberg-Richter
6. Miller-Bravais
7. Mohr-Coulomb
8. Rayleigh-Taylor
9. Tera-Wasserburg
10. Vine-Matthews

A. Paleoclimatology
B. U-Pb geochronology
C. Seafloor spreading
D. Electromagnetism
E. Crystallography
F. Thermodynamics
G. Earthquake frequency and magnitude
H. Overestimation of ability
I. Brittle rock failure
J. Fluid instabilities

Answers on page 73.

GEOCRYPTIC CROSSWORD 01

by Cryptonite



ACROSS

1. Nary a royalty-free 25 cents over the last 2.588 million years. (9)
5. Calcareous mudstone from a district that lost its borough. (4)
6. Loan bait turns solids into gases. (8)
7. Lava follows doctor to a large dune. (4)
9. To go backwards and be thrust up is a fault. (7)
11. Each lion turns to the north and transforms into a turtle. (9)
12. A musical murmur forming a limestone hill. (3)
16. & 17 down Peer back after 100 cobbles lost antimony through diffusion along grain boundaries . (5,5)
18. (see 5 down)
20. How the cowboy arrived, we hear, before artificial intelligence returned to a large landmass. (7)
22. Tall outcrop sounds like it ripped. (3)
23. O thy lips educate about a product of friction. (15)

DOWN

1. The hunted extract rock and make a pit. (6)
2. Hesitation after uranium, vanadium and I followed everyone and got deposited by floodwaters. (8)
3. One frazzled by a hereditary unit is pre-Quaternary. (7)
4. Aging in reverse provides a direction. (8)
5. & 18 across Upsetting core made in dig? This will make new crust. (3,5,5)
8. Confused angel is on the point of sleeping? No, sliding! (5,2,6)
10. About 100 encounter hesitation before crooked description of a horizontal fold.(9)
13. Diane Keaton initially produces radiation, we hear. (5)
14. It changes car tire and hitches a ride on a glacier. (7)
15. Tungsten leaves wretch upset to make siliceous rock. (5)
17. (see 16 across)
19. The object of Lizzy Bennet's affections can describe permeability. (5)
21. Where anticlines intersect atop Jerusalem's Rock? (4)

ROTORUA 28th - 31st MARCH 2022

16TH BIENNIAL MEETING SGA 2022

THE CRITICAL ROLE OF MINERALS IN THE CARBON-NEUTRAL FUTURE

Postponement Notice

The 16th Biennial Meeting of the Society for Geology Applied to Mineral Deposits (SGA) will now take place 28-31 March 2022 in Rotorua, New Zealand.

GSNZ is pleased to be a sponsor of this event. GSNZ members will be able to register for the SGA 2022 conference at the SGA member rate, a significant reduction in the conference registration fee.

The meeting will feature presentations on topics related to mineral deposit research, exploration, sustainable development and environmental and social aspects related to mineral deposits. The oral and poster presentation sessions, and pre- and post-conference short courses and field trips will provide a comprehensive programme.

The conference is organised by SGA with support from professionals in universities, research organisations, government, minerals industry, and service providers.

For more information visit: www.sga2022.org

GSNZ NEWSLETTER
SUBMISSION DEADLINE CHANGES

Please note that the GSNZ Newsletter submission deadlines are changing.

LAST DAY FOR SUBMISSIONS ARE NOW:

- **1ST FEBRUARY (FOR MARCH ISSUE)**
- **1ST JUNE (FOR JULY ISSUE)**
- **1ST OCTOBER (FOR NOVEMBER ISSUE)**

This will create consistency with the current 1st October deadline (for the November issue) and ease timing constraints in Newsletter production.

GSNZ HAS A NEW BRANCH: BAY OF PLENTY

A group of new and existing members has got together and formed a new branch in the Bay of Plenty. It's early days and they are yet to work out their programmes of activities but they are very keen to hear from anyone in the Bay area who's keen to join them and lend a hand.

BOOKS TO GIVE AWAY: OIL & GAS

Diane Toole, who is President of the Taranaki Geological Society and a member of the Oil & Gas Special Interest Group, advises that they have had a substantial collection of books donated by a member, and those which are surplus to the Branch library's requirements are offered to any of us who may be interested.

The list is available from Diane, wanderweg@xtra.co.nz

Geoscience Society of New Zealand on Instagram

#geosciencenz - GSNZ on Instagram!

Instagram is the third most popular social media platform in New Zealand (behind YouTube and Facebook), so the GSNZ Social Media Team decided to launch a GSNZ Instagram account to showcase Aotearoa's awesome geology to the world. We have been busy trying to upload photos from around the country that present a variety of interesting rocks, fossils and landscape features, captioned with short snippets of information. Unfortunately, our team also all have day-jobs and can't spend their days roaming the countryside in search of photogenic rocks (however much we would like to!!)

So...WE NEED YOUR HELP! If you have some photos you want to share, or perhaps a "what rock/fossil is that?!" type question, you can email them to us at photos@gsnz.org.nz and, pending review, we'll put them up on Instagram to share with the wider geoscientific community (with full credit given to you of course!)

Our number of followers is slowly increasing, and we hope in time that the GSNZ Instagram will be a place for people, anywhere and everywhere, to visually explore the geology of New Zealand and exchange their knowledge and experiences through photo comments.

Check out our progress at www.instagram.com/geosciencenz/ or tag us using #geosciencenz!

GSNZ CONFERENCE 2021

30th NOVEMBER- 2nd DECEMBER **MASSEY UNIVERSITY, PALMERSTON NORTH**

The Geoscience Society of New Zealand annual conference is to be held in Palmerston North from 30 November to 2 December 2021. Following the highly successful face-to-face 2020 conference in Christchurch, we are committed to making every effort to run the conference as normally as possible within any COVID restrictions. The conference will be held on Massey University's Turitea Campus and will include oral and poster sessions, an evening public lecture, pre-conference workshops and several post-conference field trips.

Online presentations will be possible for presenters overseas unable to attend in person, and in case of heightened COVID restrictions at the time of the conference we will have the capability to switch to a fully virtual format.

The annual conference is the ideal opportunity to meet with people, network, and interact face to face with fellow researchers. This year, the conference commences on the Monday evening with an Icebreaker function and will include an informal barbeque and formal conference dinner on Tuesday and Wednesday, respectively. The large seating capacity of the conference dinner venue guarantees room for everyone and we sincerely hope that as many students as possible will attend that function. There will also be numerous lunchtime breakout sessions, meetings, and workshops.

We look forward to welcoming you to Palmerston North in November for what we hope will be another very successful annual conference.

Anke Zernack and Julie Palmer
Conference Co-Convenors
James Scott
President, Geoscience Society of New Zealand

Registration for Geoscience 2021 will be discounted for GSNZ members

To qualify for the reduced fee you will need to be a current financial, honorary or complimentary member. New members are welcome to take advantage of this benefit but your membership subscription will need to be paid prior to your registration being made.

CONFERENCE: IMPORTANT DATES

10 May 2021:	Call for sessions, workshops and SIG meetings
30 May 2021:	Deadline for sessions, workshops and SIG meetings
1 Jul 2021:	Abstract submission opens
1 Jul 2021:	Registration opens
1 Sep 2021:	Deadline for abstract submission
1 Sep 2021:	Early-bird deadline
22 Oct 2021:	Programme released

HOCHSTETTER LECTURE TOUR

DARREN NGARU KING & DAN HIKUROA

Darren and Dan are jointly recognised in this award for their outstanding commitment to, and pioneering research on the weaving of mātauranga Māori and Earth science.

By challenging notions that mātauranga Māori is incompatible with science, their research has deepened understanding of geological history, geomorphology, climate change, geohazards and human-environment interactions across Aotearoa-New Zealand.

Darren and Dan will deliver a presentation entitled:

"Encouraging plural methods and values as the foundation for cross-cultural research collaborations."

The dates have now been (mostly) established as shown below. A talk abstract and details of any supporting activity will be released very soon.

Auckland Branch: TBC

Waikato Branch: Wednesday, 21 July

Otago Branch: Tuesday, 24 August

Canterbury Branch: Wednesday, 25 August

Manawatū Branch: Tuesday, 21 September

Taranaki Branch: Monday, 4 October

Wellington Branch: Thursday, 18 November.

CALLING ALL PHOTOGRAPHY & GEOSCIENCE ENTHUSIASTS!!!

The Geoscience Society of New Zealand (GSNZ) annual photography competition is your chance to share and showcase your photographic talent and passion for Aotearoa New Zealand geoscience. By entering one of your photos into this year's categories you're in with a chance to win not only some serious geophotographic prestige, but also some great prizes!

2021 Entrance Categories and Prizes:

Photo Categories:	Adults (GSNZ members only)	Tertiary Students (open)	School Students (open)
Outdoor Geoscience:	$50	$50	hand lens
Indoor Geoscience:	$50	$50	hand lens
Comedy Geoscience:	open category with a mystery prize... 👀		

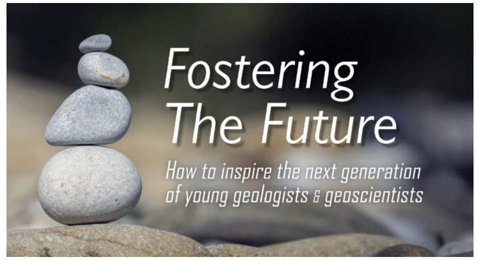
Note: All winning entries will be considered for selection as GSNZ Newsletter cover images.

How to enter:
Simply email your photo, along with the following details to events@gsnz.org.nz:

1. Your full name (and age if entering the School Students section)
2. Photo details (which category it is entering, title, date & location)
3. Photo caption (maximum 50 words)

Entries are limited to one photo per person per applicable category (i.e. maximum 3 per person). See GSNZ website for full terms and conditions: https://www.gsnz.org.nz/gsnz-events/ViewEvent/110

Entries Close 31st July



As you may have seen in a May Newsflash, we at the GSNZ are currently working on putting together a symposium to bring New Zealand school teachers and geoscientists together, to collaborate on ways to help inspire kids with earth science. Thank you to all those who responded to the request for submissions. Your ideas have helped us to narrow the scope of the symposium and to determine what dates and content will be of most value to potential attendees.

Feedback from teachers and established outreach professionals has been that the event will need to take place during school holidays so that teachers can more easily leave school to attend. It has also indicated that teachers are especially interested in developing resources relating to geohazards, and also about the geology in their local region, with many keen to learn how and where to run field trips.

The team are currently putting together a programme and approaching presenters that will help us accommodate these requests, whilst also investigating venue options for in-person attendance. Soon we hope to start approaching potential sponsors to help cover the costs of the event so that attendance (either in-person or online) will be free!

We hope the symposium will be a chance for both teachers and interested geoscientists to gain confidence and skills at presenting earth science in ways that will actively engage and inspire Kiwi kids.

Members' comments, or ideas, are most welcome and we invite anyone who wants to get involved, in helping us organise or to run the event, to email secretary@gsnz.org.nz.

Keep an eye on future Newsflashes for further updates!

EARTH: CAUGHT IN STONE 2021

ART+ SCIENCE EXHIBITION Dunedin Community Gallery, 15-22 May 2021

Nick Mortimer and Adam Martin

Earth: Caught in Stone 2021 was the eighth collaborative Art+Science project organised by Otago Polytechnic. Over two (COVID-extended) years, the project brought together 21 local Dunedin geoscientists and 20 artists, also mainly local. The project culminated in a recent week-long exhibition of geoscience-inspired artwork at the Dunedin Community Gallery, ably curated by Pam McKinlay of the Dunedin School of Art, Otago Polytechnic. The Earth: Caught in Stone 2021 scientists were drawn from the University of Otago's Geology, Geography, Zoology and Marine Science departments, GNS Science's Dunedin office, and the Otago Regional Council.

If you'd like to view the artworks, the Earth: Caught in Stone 2021 project archive is on this Otago Polytechnic Art School web page: https://tinyurl.com/EarthStoneart

From it, there are links to images of all the artworks on Flickr and YouTube, and to the exhibition catalogue on Issuu.

The ranges of styles and media on display were impressive. They included pen and ink drawings, rubbings, paint on paper wood and canvas, videography, sound recordings, LED light boxes, relief prints, sculpture, glazed pottery, zircon paint etching, knitting, weaving, tapestry, embroidery, still photographs and DIY painted rocks. The geological themes used for artistic inspiration were equally wide-ranging: paleoclimate, paleomagnetism, landscape and seascape change, schist thin sections, bryozoans, fossil wood, diatoms, penguin evolution, ripple marks, seismograms, seafloor spreading, field notebooks, Antarctica, Zealandia and Gondwana were all represented.

Personal favourites? A wooden clockwork installation representing geological time (kudos to artist Geoff Wyville for winding it every half hour and cajoling it to overcome its higher-than expected coefficients of friction), a knitted woolly hat based on a diatom, and a weaving based on a thin section of Otago Schist that reflected foliation textures and interference colours. ■

GEOBAKE 2021 WINNER

HECTOR DAY CELEBRATORY BAKE-OFF

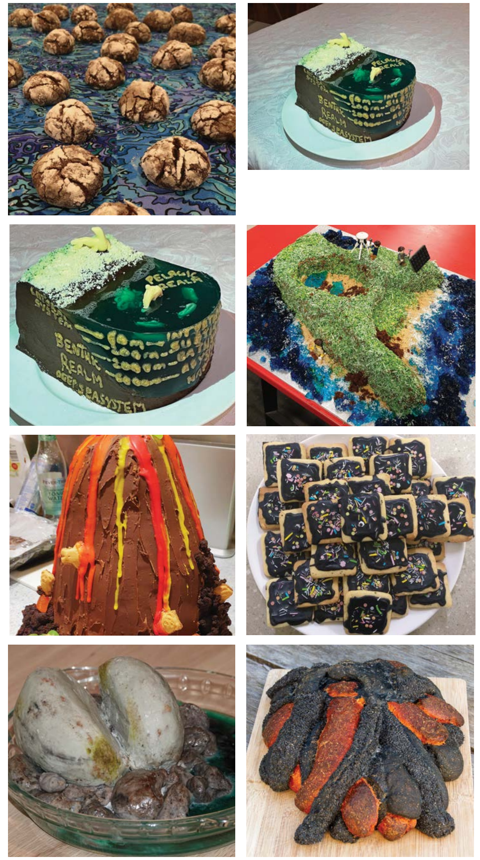
Thank you to everyone who took part in the Geobake across the country and sent in their entries to be judged. We had lots of excellent entries this year, and the decision was a close call.

We loved looking through all of your bakes and learning a little bit about the geoscience behind each one.

Congratulations to the winner of the Geobake 2021: Jamie Delano, with her wonderful Sourdough Eruption creation!

Mark your diaries, now, for the next Hector Day (March 2022) celebratory Geobake.

"This sourdough bread loaf depicts a basaltic lava eruption. The lava is erupting both from a vent (top) and through subsurface lava tubes. The different dough colours/flavours represent different temperatures of lava—yellow is the hottest, orange is slightly cooler but still molten, and black is cooled, solid basalt." —Jamie Delano



A selection of 2021 GEOBAKE photos. Starting from top row at left to right: 'Moeraki Boulders' from Nick Mortimer, 'Moana Loa volcano' from Chelsea Jack, 'Jelly Bathymetry' from Kristina Arthur, 'Raoul's "Great Expedition"' from the NGMC's "Purple Shift" – Sarah O'Hagan, Andriy Legenkky, Mathew Crighton and Ashleigh Fromont, 'Health & Safety' from Michaela Dobson, 'Toka Ngawhā' from Jade Humphrey, and the uncut version of 'Sourdough Eruption' from Jamie Delano.

REFLECTIONS FROM OVERSEAS

A GEOSCIENCE STUDENT'S LIFE IN GERMANY DURING COVID 19.

Jan-Kristian Piekarski

It's a strange and very challenging life here, in Germany, compared to New Zealand at the moment— pretty much since March 2020. In our private lives, and at work, it is not easy.

After I left New Zealand in May 2020, I was on the unemployment benefit until I, luckily, got a fully-funded, 3-year PhD position (75% TVL E-13 scientific employee) at the GFZ Helmholtz Centre in Potsdam. The master's degree from the University of Otago and the international experience I gained in New Zealand was very helpful for it. So many people here (and in the whole world) lost their jobs due to Covid 19 so I was extremely happy to get the PhD position and I am very satisfied with my project. It's also a safe job for the next 3 years, which is "worth more than gold" during these times.

I had to move from Hamburg to Potsdam during one of the lockdowns. As, for example, furniture shops and hardware stores were closed during that time, it was a real challenge. They are closed again (that can happen within days) so it is very important to "use the windows of open shops" to get what you need. Essential shops (groceries, pharmacies) are, of course open, even during the lockdowns. Everything else— restaurants, cafes, cinemas, theatres etc.— has been closed over the last year until further notice.

Wearing medical FFP2 masks is required by law pretty much everywhere, except in a forest where there are no people around. You have to wear it at work, on public transport, in streets, railway stations, supermarkets, car parks etc. There are contact restrictions,

One of the last pictures of Jan in New Zealand from his last visit to the Otago Peninsula in May 2020 - less than 12 hours before his flight back to Germany.

total assembly bans in public, and dusk-to-dawn curfews. Germany has not seen things like these since WW2.

Social life pretty much stands still, except for picnics with friends or bike tours with no more than 2 people from 1 other household (that can also change daily, it probably had already changed when you read this email). It is really hard to keep track of the daily changing regulations and laws. Some of these regulations just show the helplessness of our government as some are actually good for reducing the infection risk (in my opinion). That's one of the reasons why a lot of people are having psychological issues (e.g. a lot of people - even younger ones - are too afraid to leave their flats, except doing groceries). Some even wear masks when taking a walk in a forest where there is nearly nobody around. Even though I am not doing that, I can understand why people act like that. Nobody wants to catch a virus which is unpredictable and which long-term disorders are not even known. It's very dangerous! I, personally, don't want to catch it.

In contrast to the US or the UK, our government (and most of the other EU governments) has totally failed to progress the vaccination process with no end to the never-ending lockdowns, and ever-changing regulations/laws, in sight. As we all know, the only way to end this situation is to get a vaccine (in my opinion). Most of the people here lost trust in our government concerning the vaccination process and I think that Germany totally lost its "efficiency" in this matter — it's just very sad. My only hope is that I will be able to get a vaccine within the next year. If someone offered it to me, I would take it immediately to be safe. I admit that I am afraid to use public transport (my only way to get to work) as there is always the risk of catching the virus.

In general, we have mandatory home offices but I am still going to work at least 3-4 days a week. That's because I only have a tiny flat and my computer cannot run computer programs like Arc GIS, Well CAD or PETREL. Also, laboratory work like petrological analysis or porosity-permeability investigations of drill cores are (obviously) not possible at home.

In the last few days, they introduced a mandatory attendance list which you have to fill out in advance. If all spots are gone, you are not allowed to go to work on that specific day. That's a good way to reduce the infection risk even though there will be delays in your work. My employer has a very good and efficient strategy for employees during these times. It works very well and we are all very satisfied with it. There are, of course, delays in work and research - but that's okay. Pretty much everything moved into a digital mode — Zoom and Skype have become the most important tools at work at the moment, with both advantages and disadvantages.

During my free time, I do a lot of sports (biking, kayaking, running) to stay fit and strengthen my immune system.Looking forward, I will definitely be back in New Zealand, once this is over, to check on my personal belongings which were left behind when I left. I was not allowed to carry a suitcase as I had to transit via Australia with special permission. (Australia didn't allowed foreigners to enter or transit via their country —only on special request). It was quite challenging as they had to double-check the permission when I arrived there which cost quite a bit of time). But I made it. All in all, it was a 4.5-day journey back to Germany - in the middle of the first wave.

I really appreciate my (international) experience at the University of Otago and would like to thank Ewan Fordyce (my supervisor), Nick Mortimer, and Daphne Lee who always supported me in my research. When the Covid-19 crisis is over, and I finish my PhD in a few years' time, I might return to New Zealand for the long-term. ■

WHAT ARE WE DOING: CLIMATE CHANGE?

Roger Brand

What are we doing : Climate Change?

What can we geoscientists do to mitigate the effects of adverse climate change?

And what am I doing?

Last week's report, from the Climate Change Commission, is yet to be scrutinized in detail and the suspected hardships remain in the manyana basket.

In the interim, I'd like to throw into the ring another take on where we are headed with fossil fuels (Paul White, Newsletter March 2021).

By now we know what we have to do to achieve anything like the goals set in Paris, and then in 2018, IPCC S15. As a clear reminder, the slogan of the 50x30 Coalition (International Cryosphere Climate Initiative) says 50% emission reduction by 2030.

That's definitely tomorrow.

The final statement in Paul White's article was perhaps the most pertinent since taxing carbon will have a profound effect on fossil fuel usage. We have all seen the oil majors writing down their assets by billions (e.g. Shell $22 billion) and being made publicly accountable to their shareholders, and this the result of a realization that there are increasingly high capital costs for high-carbon energy projects.

Hubbert in the 1950s did not include stranded assets in his appraisal of 'peak oil'. It is required that c.80% of remaining fossil fuels will need to remain in the ground for us to achieve the 1.5^{o} target. Where the calculated world emissions in Paul's Table 5 could get us is difficult to contemplate.

Not attending last year's conference in Christchurch means that I missed sharing ideas and discussing fossil fuel issues. The previous year's well attended public lecture on 'The Science of Sea-Level Change, Impacts and Management' made clear the likely risks and consequences and then the mitigation practices that we, in NZ, will have to employ. GNS also rose to the occasion promising to lead by example in Environment and Energy Futures.

Now where are the research projects that have eventuated from the 2019 discussion? Certainly very few indeed that I can see from the published Abstracts and Poster titles.

I may of course be missing the point and really we need this level of geoscience expertise to inform the public, and without this we have no platform from where we can advise Government with Science Based Targets.

So what am I doing to help the cause on this low alternative energy day? (no wind or sun, just rain!) Sitting close by our woodburning stove enjoying heat given out by dry wattle. Goat farming in the Waimamaku hills means I walk at work although the rest of rural living needs to go electric (chainsaw, quad, car, tractor?); rural living just doesn't happen without a vehicle.

But I am also aware that alternative transport and power means more investment in mineral exploration and production. The IEA estimates that by 2030 the value of critical minerals will exceed that of coal, although part of the transition will involve recycling of materials with a considerable reduction in waste generation and disposal. Investment in alternative energies including CCUS (Carbon Capture Utilisation and Storage) will exceed that in oil and gas by 2030.

Without a better understanding of the new Ngawha geothermal plant I find it difficult to offer coherent solutions to the voluminous CO_2 which accompanies the 25MW generation. Maybe the Kaikohe Berryfruit industry will benefit. It is the only clearly related CO_2 sequestration project. CCUS has been universally toted but uptake in NZ by the energy industry has been muted, ostensibly due to our leaky subsurface repositories.

Ecosystem health of the West Coast harbours (e.g. Hokianga) is recognized to be compromised by high sediment input from the deforested and easily eroded hinterland. I work with a group aiming to restore some of the imbalance by planting lots of trees; somewhere there will be credits. With rising sea levels, sediment is expected to be progressively ponded and stabilization of the inundated coastal/estuarine plain will become ever more needed.

Since retiring from the industry I have changed to water as my preferred medium with the target of my work in resource estimation both potable and needing to be treated sustainably. The complexities of newly accessed aquifers in the Far North (e.g. Aupouri paleo-tombolo, fractured Tangihuas) has required geological input which appears to have been missing from previous Resource Consent applications.

Now the rain has stopped, freshwater has replenished the earth and I'm on for chopping more firewood. Manual tasks always opens your eyes to what is really going on.

Roger Brand
brand.r@xtra.co.nz

P.S.
Recommended reading: Mark Carney, Value(s)

Thank you Janis for the beautiful fractured liesegang.

GEOPHOTOGRAPHERS

DIVIS AND HOMER: A TALK BY SIMON NATHAN

Janis Russell

I had the good fortune to listen to the talk, given by Simon Nathan, about two geophotographers: Joseph (Jos) Divis and Lloyd Homer. This one in Christhurch was the first of six, hosted by AUSIMM, in centres from Dunedin to Auckland.

After the drinks and nibbles, generously provided for us, many Friends of Waiuta and a couple of extras sat down to an interesting account of some fascinating geophotographic history.

Both of these men encapsulated, on film, very different perspectives of our geoheritage, in Aotearoa / New Zealand — below ground and high above it. Jos captured the gritty human face of mining, in the early 20th century, documenting an insider's view of a rarely seen part of our social history. Years later, Lloyd's aerial photography (without a drone) enabled us to see our landscape anew and marvel at its beauty.

Jos was a Bohemian immigrant who worked as a coal miner in the small West Coast settlements of Blackball and Waiuta as well as Waihi. His job may have been in mining

The screen shows Jos's images are well composed and of surprisingly high quality.

Simon Nathan speaks to the group about the work of the two geophotographers, in Christchurch.

but his calling was in photography. Jos's understanding and clever use of lighting makes for fascinating viewing.

Simon recounted that he was a quirky chap—quite dapper and inclined to appear frequently in his own photos. It takes great skill to portray the gritty, grimy conditions underground and turn them into works of art with their own sense of beauty. Peering into the not-so-distant past, at the bleakness of existence in a particular time and space, it is all-at-once mesmerising and uncomfortably voyeuristic. These personal moments, laid bare, invite comparison with the pioneering photography of Thomas Annan—a Scotsman who photographed the dismal living conditions on the streets of Glasgow in the late 19th century.

Much later, another geologist became known as 'disaster man' for his ability to arrive quickly with cameras in hand, to record one natural disaster or other as they unfolded. Lloyd Homer worked for the NZ Geological Survey (now GNS) for 35 years and gave us unprecedented images of our land from above.

These days, of course, there is less need to lean out of planes or helicopters, as Lloyd did, to get those amazing shots. Technological advancement allows us to get those birds-eye views from the relative safety of the ground, and in much greater resolution. But rather than diminish Lloyd's efforts, this only serves to amplify the appreciation for Lloyd's contribution and the risks he took to provide it.

Simon's talk did justice to both photographers by juxtaposing them in time, altitude, and mode of operation.

Lloyd in aerial action.

Having written extensively about these men, in his books, Simon has ensured that their unique photographic contributions will not be lost to time. ■ Check them out:

Through the Eyes of a Miner: the Photography of Joseph Divis (2016)

Flying high: the photography of Lloyd Homer (2019)

**Flying High is available in limited numbers from GSNZ publications and webstore. Secure your copy now!

GEOPHOTOGRAPHY

CALL FOR ARTICLES

Each issue of the GSNZ Newsletter will feature a set of articles on a theme.

The theme for the next issue is Geophotography, and coincides with the announcement of the winners of the GSNZ Photo Competition 2021 (entry details on p64).

Articles on any aspect of geophotography including technical, experiential, artistic, historical, biographical and others, will be welcome.

GEOSCIENCE QUIZ ANSWERS (from page 58:

1D, 2A, 3H, 4F, 5G, 6E, 7I, 8J, 9B, 10C

CHILDCARE PROVISION

AT THE GSNZ NATIONAL CONFERENCE: WHAT THE PEOPLE SAID

Kat Holt: GSNZ Vice-President Email: vp@gsnz.org.nz

In February 2021, the National Committee received a letter prepared by the University of Otago Diversity and Inclusion Working Group urging for onsite childcare to be provided at future GSNZ annual conferences. This letter was signed by 104 Geoscience researchers from within Aotearoa New Zealand and beyond, including ~53 members of the Society.

The text of the letter reads as follows:

> *"We, Earth scientists, call on the Geoscience Society of New Zealand to ensure that child care be provided on site at future national Geosciences Conferences.*
>
> *Conferences are vital, especially for early career researchers. These meetings allow scientists to present their work and build new collaborations or cement existing ones. Often the early career stage coincides with the time when some will be thinking of starting a family. Having young children to care for can make it difficult to attend conferences, which requires extra help. Some families are fortunate enough to be able to draw on the assistance of relatives or friends but too often this is not the case. Not being able to attend conferences and meetings can be the genesis of a lifelong disadvantage and likely contributes to the skewed ratio of male and female researchers in our geoscience community.*
>
> *The Geoscience Society of New Zealand must support Earth scientists who are parents of toddlers to attend conferences (as it is provided for other international conferences), to avoid discrimination against a part of the scientific community.*
>
> *This letter was prepared by the Diversity, Equity and Inclusion Working Group, Department of Geology, University of Otago and is signed by researchers from throughout New Zealand's Geoscience community and beyond:" (followed by signatories).*

The National Committee agrees in principle with the important points raised in this letter and we have sought to understand the perspective of the wider membership as to how we can best address these issues. Thus, in February we conducted a survey of the membership to assess the following:

- Barriers to conference attendance as a parent (e.g. childcare availability vs cost of childcare).
- The degree to which the wider membership supports the idea of providing on-site childcare.
- How the wider membership would like to see conference childcare funded.

A link to the survey was distributed to all Society members on the 16th of February 2021. It closed one month later. A total of 111 responses were received (approximately 15.4% of the total membership).

Here is a summary of the key findings of the survey:

- Approximately 55% of respondents expressed that childcare responsibilities have challenged or limited their ability to attend GSNZ conferences at some point during the year.

- Respondents ranked a lack of suitable childcare at the conference venue, and the costs associated with childcare, as the first and second most significant barriers preventing parents from attending, or participating to their desired degree, GSNZ conferences, respectively.

- 93% of respondents agreed that on-site or close to site childcare facilities should be offered at future GSNZ conferences.

- Views on covering costs of such childcare were split across several, however, it can be said that the majority of respondents (72%) thought that it was appropriate for some level of support for childcare costs to come from the conference budget.

- Out of the 111 respondents, 6 indicated that they would be interested in using childcare facilities at the 2021 conference.

To view a copy of the full survey and responses, please go to the Society website (www.gsnz.org), navigate to the 'News and Events' page, and then select 'Newsflashes and other news'. A copy is available for download here.

In light of the majority support for conference childcare in some form or other expressed in the survey results, the National Committee, in conjunction for the LOC of the 2021 GSNZ conference, are working towards the following initiatives:

- Securing places at an on-site childcare facility for the duration of the 2021 GSNZ conference, to be held at Massey University, Palmerston North from 30 November to 2 December 2021. These will be available on a first-come, first served basis. More details will be provided once conference registration is open in early July.

- Assessing what funds are available to provide grants to subsidise childcare costs, and developing eligibility criteria and an application process for such grants. Again, more details on these grants will be available once registration is open.

Assuming this model is successful for 2021, we would look to encourage the LOCs of future GSNZ conferences to explore options for connecting delegates to on site or near-site childcare facilities. However, we acknowledge that depending on conference venue, this may not always be feasible, for example in the instance where there are no suitable (i.e. Ministry of Education approved) childcare facilities in proximity to the conference venue.

We hope that these changes will make conference attendance easier for our members who are or will be experiencing the joy of parenthood!

THE INTERNATIONAL UNION

OF GEOLOGICAL SCIENCES AND NEW ZEALAND

Nick Mortimer: NZ IUGS Delegate, Dunedin

The International Union of Geological Sciences (IUGS) is a global scientific union which promotes and supports Earth Science research. New Zealand is a member of IUGS through the Geoscience Society and the Royal Society of New Zealand. The IUGS Annual Report for 2020 is now out.

The latest IUGS E-bulletin 174 contains a letter from IUGS President John Ludden, and news items from IUGS Commission on the History of Geological Science (INHIGEO), Initiative on Forensic Geology (IFG), International Geoscience Programme (IGCP), IUGS books, Tectask, Subcommission on Quaternary Stratigraphy and the Commission for the Management and Application of Geoscience Information (CGI).

The most recent issue of IUGS's open access journal Episodes (volume 44 no 2) contains articles on two new stratotypes and GSSPs, an alternative view of the Anthropocene, reports on IGCP649 (Diamonds and Recycled Mantle) and, IGCP662 (Orogenic Architecture and Crustal Growth), an article on social responsibility in geology, and more.

Hardcopy readers of the GSNZ newsletter can find links to the above publications on the main IUGS website https://www.iugs.org

UNESCO IGGP NEWS

INTERNATIONAL GEOSCIENCE AND GEOPARKS PROGRAMME

Hamish Campbell and Janis Russell: NZ National IGCP committee

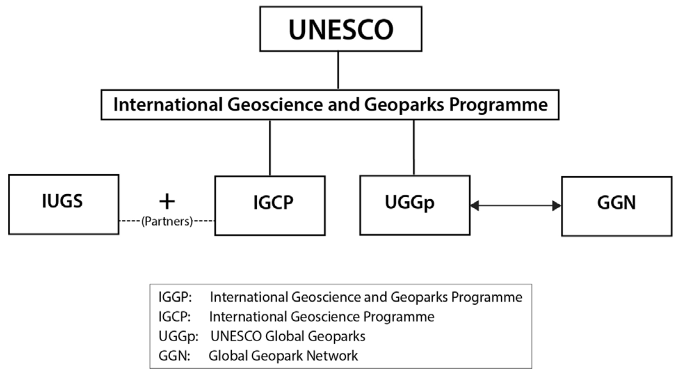
UNESCO and the IGGP

UNESCO is the only United Nations organization with a mandate to support research and capacity in Earth Sciences. The International Geoscience and Geoparks Programme (IGGP) is one of UNESCO's flagship programmes. The IGCP, in partnership with IUGS, is one of the two pillars of the IGGP. Since its inception in 1974, New Zealand earth scientists have been involved in IGCP projects and a number are actively involved in live projects, which typically have a lifespan of 3 to 5 years.

As everyone will appreciate, since early 2020, the Covid-19 epidemic has put a stop to most overseas travel globally and has impacted on international scientific collaboration at all levels, IGCP projects included. IGGP administrators at UNESCO in Paris have thoughtfully instigated a new line of communication, namely an IGGP Newsletter.

For those interested, please check out IGGP Newsletter Issue 1 (January-May 2021) at https://tinyurl.com/IGGPIssue1

The content of this issue addresses:
1) The IGCP Council,
2) The IGCP and the SDG's - sustainable development goals,
3) IGCP Projects Outreach Work,
4) New UNESCO Global Geoparks,
5) International Geodiversity Day,
6) UNESCO – IGGP Consultation.
Note that as of April 2021, there are 8 new Geoparks so there are now 169 Geoparks in 44 countries.



EARTH INDESTRUCTIBLE

By Paul Williams

Amongst the doom and gloom
take comfort in the indestructibility of Earth.
A blue planet, swirling, laced with clouds,
endlessly orbiting,
traversing the Milky Way.

Planet-wide species loss confronts us.
'Extinction Rebellion' provoked by despair.
Yet on Earth's ancient face
these are but passing scars.
Just new extinctions,
amongst many gone before.

In the great realm of space
Earth carries on regardless.
Asteroids will strike it.
New species will cover it.
We are and always were irrelevant
to the cosmic spinning of our globe.

Who cares if you or I should reach 100,
when Earth surpasses 4.5 billion?
Our lives are just loans from planet Earth's library of life,
and will be returned,
no fines, no choice,
and then like leaves will be recycled.

Perchance in some far-off time,
on a global tour, alien visitors will discover
lego blocks, computer chips, and plastic pressed in rubble.
Middens and habitation sites from a distant earthling age,
Anthropocene, avarice-driven to destruction.

But we're not all cynical and lost, re-wilding's in the air.
We still have banks whereon wild thyme doth grow
and forests, too, with primates free to roam.
We've gone too far and know it, yet dither in response.
Thank God for Youth who lead the way, who goad and push us on. ■

Devonport,
20 May 2021

ROMANCING THE STONES:

FINDING BEAUTY IN THE BEDROCK

By Janis J. Russell

I see you
The veil of objectivity
we drape you in
belies your tortured past

I hear you
Tumbling vociferously
thundering endlessly
pulverized to dust

I feel you
Jaggedly striking
an angular figure
and textured frame

I see you
Embracing ancient
lifeless forms which
mark your passing years

I hear you
Thrum and pulse
scrunch and crackle
as blazing spasms flow

I feel you
Cool, smooth satin
glides across my cheek
like curling stones on ice

I see you
Bright and bejewelled
glinting beacons ushering
us across the abyss

I hear you
Groan, creak and screech
the belly-aching refrain
from a twisted visage.

I feel you
Crumpled and gritty
stoic astride
your innermost flux

I see you
Pretty pictures
painted in scorched film
adorn your face

I hear you
Harmonic vibration
a mellow hum
murmurs through time

I feel you
Strained and supportive
an edifice
beneath my feet ■

ODE TO THE CHATHAMS

By T.C.Mumme

I've come from an island so far away where the sea is always blue,
And I sit here thinking of today cause already I'm missing you.
And where the weka calls as the falcon falls down from the stormy sky,
I see you stand there against the wall never knowing the reason why.
You're just a lonely face from a forgotten race, just a fading memory,
And I saw my Queen inside your face but do you think of me,
As I stumble through this city night feeling oh so blue
Oh God I'm leaving on the next flight, I'm coming back to you. ■

Read Terry's obituary on p85 of this issue ▶

Geoscience Society of New Zealand

REMEMBERING JACK GRANT-MACKIE (1932-2021)

A GSNZ TRIBUTE

Jack Grant-Mackie died on the 20th February this year. His funeral was held at Waikumete Crematorium on February 26th where his life was celebrated by his family, colleagues and former students and members of the many other groups he was associated with.

GSNZ wishes to compile a tribute to Jack, who was a Life Member and former President of the Society. This will be a stand-alone digital GSNZ Miscellaneous Publication with limited printing ofhard copies planned for a nominal price of $15–20 per copy (incl. GST and postage). The final price will depend on the level of interest and the number of written tributes received.

Donald MacFarlan has agreed to act as Compiler. In terms of style and content, it will be similar to the dedicated GSNZ Newsletter Issue 19A (2016) compiled by Cam Nelson in 'Remembering Bob Carter'. If you wish to prepare a written tribute to the memory of Jack Grant-Mackie, please communicate directly with Donald at: donald.macfarlan@xtra.co.nz

Deadline for tributes is 30 September 2021. Publication is planned for towards the end of 2021.

JANE MARGARET SOONS

(BSc Hons Sheff, DipEd Sheff, PhD Glas, DSc Glas)

18 June 1931 – 8 September 2020

Jamie Shulmeister: james.shulmeister@canterbury.ac.nz

Jane Soons was born in England, in Lincolnshire, in 1931. She was the daughter of a railway worker and a very bright student. She won a scholarship to Kesteven and Grantham Girls' School which she attended at the same time as Margaret Thatcher. In 1949, she made it to the University of Sheffield on scholarship. Her choice of Geography was serendipitous but once chosen she realised that she had found her niche. She undertook a Diploma in Education and followed up with a PhD at the University of Glasgow, where she worked on 'The geomorphology of the Ochil hills' , a glaciated hill range near Stirling in Scotland.

Her PhD was awarded in 1958. Following this she held tutor roles at a couple of U.K. universities but discovered that she was being overlooked for academic positions in favour of male candidates. When George Jobberns, the foundation Professor of Geography, offered Jane a position at the University of Canterbury, she accepted.

Jane sailed to New Zealand on the Rangitane and started at Canterbury in 1960. Eady on, Jane moved into mapping the glaciation of the Rakaia. Those were challenging days. The base maps that she worked with had no contours but the determination of the glacial correlations depended on accurate measurements of relative dips of terraces and terrace elevations. Her mapping is elegant and her work stands the test of time.

Jane Soons receiving the ANZGG (Australia, New Zealand Geomorphology Group - the regional affiliate of the International Association of Geomorphologists) Bronze Medal. The ANZGG bronze medal is awarded to distinguished geomorphologists who have made a significant contribution to the ANZGG through sustained interest and participation in conferences and other activities of the organisation. Jane was awarded the medal in 2014 but didn't make the ANZGG meeting. I presented the medal to her at the Shilling Club at the University of Canterbury later that year.

Over the decades, she contributed across a wide range of physical geography topics including periglacial phenomena, coastal research and micro-climate and erosion. In addition to the excellent work she completed, her other major attribute was her mentoring of students. She was of course an amazing role model for female students at a time when there were few female academic role models but she was also just a general inspiration for several generations of geomorphologists in New Zealand, male or female.

Her undeniable excellence overcame any inherent biases and Jane was appointed Professor of Geography in 1971. She was the first, and for many years the only, female professor at Canterbury. Jane's reputation rapidly became international. This was recognised through becoming President of the International Association for Quaternary Research (INQUA), the peak organisation in her scientific discipline. She also co-wrote the book Landforms of New Zealand with Mike Selby. This book is still a benchmark in New Zealand geomorphology.

I first got to know Jane near the end of her academic career. I was a newly minted postdoc who had actually turned up to work on a coastal project with Bob Kirk. I have always loved glacial geomorphology and I soon linked up with Jane. It was the beginning of a 10-year collaboration and nearly 30 years of friendship. Later, I had the temerity to re-examine the Rakaia Valley as part of my work on glaciation in the South Island of NZ. Characteristically, Jane was very generous with her time and support of this work.

After her retirement, Jane became very active in coastal matters on Banks Peninsula. She had little tolerance for sloppy thinking and had very forthright views on the attempts to establish a channel between Lake Forsyth/ Wairewa and the sea. She and Dr. Maree Hemmingsen campaigned on taking a geomorphological approach to the opening of the lake. It was one of the few areas where she did not prevail, but time is proving her position right.

Jane's driving was legendary and everyone who knew her has a story or three. By legendary, I mean she drove like she was on an episode of 'Starsky and Hutch'. In my case, the most memorable driving event was a graduate student trip to the West Coast. We got caught behind a bus full of university students going up Porter's Pass. There was some rude behaviour in the back seats of the bus and Jane was furious. She overtook the bus on a blind corner on the pass, threw the van sideways into a hand-brake stop in front of the bus. Jane stomped off the van and on to the bus where she gave the offending occupants what for. It was a very impressed but intimidated crew of grad students (and a postdoc) who were very quiet on the rest of the trip over to the West Coast.

Jane took up bowls as a retirement hobby and was soon a mainstay of the Diamond Harbour club. She was ladies captain and a great competitive player. She was made a life member for contributions to the club. This was hardly a surprise. When Jane put her mind to things she simply achieved. Jane's health was good until the very last year. She was a very independent person and she maintained her independence for as long as possible.

Jane was a foundational figure in modern geomorphology in New Zealand, a mentor for many young geomorphologists, an enthusiastic lecturer and an amazing role model for generations of female scientists. She will be hugely missed by colleagues and ex-students. ■

Jane at the Poulter Moraine in the Waimakariri River on a fieldtrip in November 2007.

TERRENCE CLIFFORD MUMME

19 June 1950 – 22 May 2020

Hamish Campbell: H.Campbell@gns.cri.nz

Members of GSNZ will be saddened to learn of the death of Terry Mumme, a man of unusual colour and conviction. He was one of those unforgettable larger-than-life characters who spoke his mind, commanded attention and loved a party. He died at his home in Spring Lodge, Upper Hutt, on 22 May 2020 as a result of complications relating to Multiple Sclerosis. He was 69. Because of the strictures of the Covid-19 epidemic during 2020, a celebration of Terry's life could not be held until 20 June 2020. This was held at The Pickle Jar in suburban Karori, Parkvale Road, Wellington. This watering hole was well-known to Terry in its days as the Terawhiti Arms.

Terry Mumme on location, Chatham Islands; GNS Science magnetic survey. Photo: Hamish Campbell, October 1995.

Terrence Clifford Mumme was born in Wellington, the second child and second son of Desmond and his second wife Esther (nee Wills) Mumme. His Mumme grandfather emigrated from Germany as a 20 year old. His father Desmond was the youngest of five children and became a tradesman specializing in sign writing and painting. Terry was greatly influenced by his parents. His father was a skilled craftsman with an exceptional eye to detail. Terry inherited this same trait and it held him in good stead as an instrument-toting geophysicist. None could surpass the precision and accuracy of a Terry Mumme measurement. His mother Esther was creative with an avid interest in literature and music not to mention a love of animals. Terry inherited these same interests from his mother. Terry grew up in the constant shadow of his older brother Garth (b. 1949) whom he adored. Tragically, Garth died in 1979 while on a trip in New Guinea. Terry never really recovered from this loss. Terry is survived by his two sisters, Kathryn (oldest in the family, half-sister to Terry) and Lois (youngest in the family), and their children, Terry's three nieces and two nephews. He never married.

Terry had a blissful childhood, growing up on The Ridgeway, Mornington, Wellington. He often spoke warmly of those days and he formed many enduring close friendships. He was educated at Ridgeway Primary School, South Wellington Intermediate and Rongotai College (1964-1968). On leaving school he worked for an insurance company (1969), but quickly saw the light and attended Victoria University gaining a BSc in geology (1970-1972). Suitably armed with a qualification, he was snapped up by Geophysics Division, DSIR, as a Science Technician, thus commencing a professional career in geophysics that would span 23 years (1973-1996). In 1977, he was significantly elevated in status from 'technician' to Scientist. This was no small achievement and was recognition of his ability to think and perform as a scientist. Between 1990 and 1992, DSIR was transformed into Crown Research Institutes and Geophysics Division became part of GNS Science. Sadly, Terry was a casualty of corporate 'restructuring' in 1996 and was made redundant at age 46, a cruel blow, but an even crueller blow came in 1998 when he was diagnosed with Multiple Sclerosis (MS), a debilitating disease that dominated the latter third of his life.

Terry thought of himself as a loyal and dedicated member of Geophysics Division, one of Trevor Hatherton's men, and after Trevor, one of Fred Davey's men. With the morphing of Geophysics Division into GNS Science, nothing was ever quite the same for Terry. His professional working life was concerned with four major activities as follows: 1) geophysical rock property measurements including density, porosity, sonic velocity, magnetisation, thermal conductivity, electrical resistivity and strength tests; 2) gravity and magnetic surveys; 3) geotechnical surveys and 4) paleomagnetic studies. He worked on projects all over New Zealand and was co-author on 30 publications. He made a lasting and valuable contribution to our understanding of New Zealand geology.

Terry's life in professional geophysics came to a close in 1997. He then moved to Queenstown (1997-2002), Nelson (2002-2004), and then the Wairarapa where he acquired the 'Buckhorn Bar & Grill' in Carterton (2006-2008). With deteriorating mobility as the MS took its toll, Terry ended up residing in healthcare facilities in Masterton from 2011, and ultimately Spring Lodge (2015-2020) in Upper Hutt.

Terry was much more than a geophysicist. He had a fast brain and a superb eye. He was a natural athlete and a keen sportsman and played tennis and cricket in particular. He was fiercely competitive and loved to participate in games. He was also an outdoorsman, skilled in bushcraft, tramping, skiing and mountaineering. He also fancied himself as a bard and minstrel. Accordingly, he wrote poetry and ballads and played the guitar. He was theatrical and would dress to part, often as a rock-star or a cowboy. He even tried his hand at acting as an extra in 'Lord of the Rings', priding himself in the fact that he was the only Wild Thing who did not require any make-up! He had a remarkable memory and was completely familiar with contemporary culture. He was also well-known for his affectations, enthusiasms, expressive outbursts and vices, not least smoking. He wore his heart on his sleeve and despite all his odd behaviours he was well-liked and loved.

With acknowledgements to Kathryn McLean and Lois Carter, Terry's sisters. ■

Read a poem penned by Terry on p81▶

OBITUARIES

GUY STAFFORD LISTER

(BSc, MSc Hons Waikato NZ, PhD ETH Switz) — A SWISS-BASED KIWI

28 June 1946 – 2 February 2021

Cam Nelson: campbell.nelson@waikato.ac.nz, candmnelson@xtra.co.nz

Guy Lister undertook BSc and MSc degrees in Earth Sciences at the University of Waikato, New Zealand during the 1970s. He then went on to complete a Doctorate degree during the early 1980s in the Geological Institute at Eidgenössische Technische Hochschule (ETH) in Zürich, Switzerland. As a long-time friend of Guy, and knowing he has many other Australasian contacts, including Earth scientists, I want to record and share here a few aspects of his life and working career.

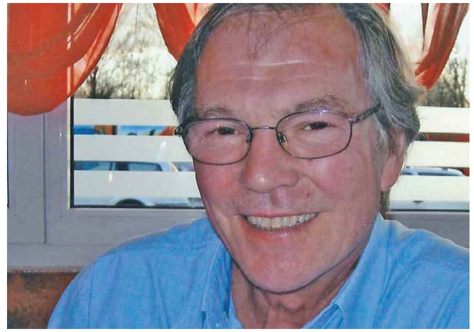


Image from Brigitte Cuperus

Guy Lister about 2010

Guy was born in Auckland on 28 June 1946 to parents with an English military background who had emigrated that year from England to New Zealand where they purchased an orchard in the Hastings/Havelock North area in Hawke's Bay. Guy's brother Terry was born in 1947, and his sister Michele in 1952. Primary schooling was at Havelock North (1951-1959) and secondary schooling at Hastings Boys' High School (1960-1963). The untimely death of Guy's father in 1963 led to Guy, age 17, leaving school to work first on the family orchard, then on a sheep farm in central Hawke's Bay, and later at the region's freezing works. During 1966-67 he trained as a meat inspector in Wellington. But an OE was calling, and Guy left by ship for England where he spent the next three years working and travelling in Europe. However, news of the sudden death of his mother in 1969 saw Guy return to New Zealand, especially to lend support to his younger sister, Michele.

On the sea trip back to New Zealand one of those small "life changing direction" moments arose. Guy was seated at the same table as a geologist who had been working at Pompeii, the buried Roman city near Naples in Italy that was overwhelmed by pyroclastic surges from Mount Vesuvius in AD79. He was fascinated by the stories told and the working life of a geologist, and the seed was sown for him to want to learn more about the Earth sciences. But this aspiration had to be put on hold for a short while because he was financially broke and needed to settle down and find accommodation and a job—including as a butcher back at the Whakatu Freezing Works near Hastings. An appropriate qualification to attend university was also needed and in 1971 he undertook correspondence study for the University Entrance examination. At the same time he slowly built up some savings so as to fund at least the first year of study at university.

At the age of 26, then regarded as a 'mature student', Guy enrolled in 1973 in the BSc degree programme at the University of Waikato, majoring in Earth Sciences. He worked exceptionally hard, passed courses with very good grades, and especially excelled at the practical tasks associated with laboratory and field projects. During the university summer recesses Guy returned to Hawke's Bay to work again as a butcher at the Whakatu Freezing Works and to save money to continue to support his university studies. He and a New Zealand friend whom he had travelled with in Europe began building a house at Waimarama, on the coast out from Havelock North. This part-time building project was to continue throughout his Waikato university years, and gave Guy an accommodation base whenever he was over in the Hawke's Bay region. Guy was naturally gifted when it came to practical manual work, self-learning the fundamental skills required for fixing car and motorbike engines, undertaking wood- and metalwork projects, and in drawing and design techniques. Old motorbikes and cars were a particular passion, and over time his basement garage at the Waimarama property housed his favourites, a 1959 AGS 650 cc motorbike and 1962 and 1963 Jaguar MKII saloon cars.

On completion of his BSc degree in 1975 Guy was inspired to continue into the MSc programme in Earth Sciences at Waikato, enrolling in 1976. By around this time I had begun a research project studying the nature and origin of the bottom sediments in some of the many Rotorua lakes, using the department's recently built A-frame barge as a sediment sampling and coring platform. Guy's frequent travels between Hawke's Bay and the Waikato had him passing the northern shores of Lake Taupo, and he suggested he would be keen to investigate the sediments and sedimentation processes in New Zealand's largest lake as an MSc thesis research project. I agreed and supervised the study. Several weeks of field work were spent on the lake, at times in arduous weather conditions, using the barge and its attendant run-about dinghy to collect surficial and cored bottom samples and record other lake data. Guy's practical skills for diagnosing and fixing any mechanical problems that arose during this often demanding period of fieldwork came to the fore. In 1978 he produced an excellent thesis titled "Sedimentology of Lake Taupo, Central North Island, New Zealand" (Lister 1978), and in 1979 he graduated with MSc(Hons) in Earth Sciences. Many years later, Guy and I published the main results of his Lake Taupo work in the New Zealand Journal of Geology and Geophysics (Nelson and Lister 1995).

Image from Mike Vennard.

The Earth Sciences barge and beached support dinghy at Lake Taupo in 1977.

Following the MSc degree Guy was considering his next work options when another "by chance" event happened. Earlier, when in England, Guy had met a Swiss girl and he stayed in contact. She travelled to New Zealand a couple of times and in 1979 he decided to visit her in Switzerland. Among her acquaintances was a geologist who was aware that a Professor Ken Hsü at ETH Zürich had access to funding to retrieve and scientifically analyse sediment cores from Lake Zürich following a geophysical seismic reflection study of the sub-bottom lake structures. Coincidentally, Professor Hsü had visited New Zealand and briefly the University of Waikato during Guy's undergraduate years, so Guy was aware of the name which had become a very well-known one in the Earth sciences discipline in the 1970s. Through his association with American contacts, Ken Hsü had in 1970 led the first Deep Sea Drilling Project research cruise into the Mediterranean Sea basin aboard the international drill ship Glomar Challenger. Amazingly, drill cores from well below the modern sea floor recorded very thick deposits of salt beds that were hypothesised to have formed from the complete desiccation of the Mediterranean basin, some 6-5 million years ago. This major event became known in geology as the Messinian Salinity Crisis.

Armed with his Lake Taupo sedimentology research experience, Guy approached Professor Hsü about the proposed sediment core-geological study of Lake Zürich. Following discussion, which apparently included Hsü prompting Guy to chat about, of all things, the concept of geosynclines in geology, Guy was appointed in 1980 as a paid assistant and doctoral candidate within the Swiss lakes research programme. He quickly adapted into his new role and working environment, including the immediate need to learn the German language. By 1985 Guy had successfully completed the ETH requirements for the doctoral degree with a dissertation titled "Late Pleistocene Alpine Deglaciation and Post-Glacial Climatic Developments in Switzerland: the Record from Sediments in a Peri-Alpine Lake Basin" (Lister 1985).

By this stage, Guy's fundamental contributions to the work of the limno-geological group at the Geological Institute at ETH had become well established. Consequently, his employment was continued at ETH as a scientific collaborator responsible for the co-ordination of the various limno-geological projects involving up to nine permanent employees that were being undertaken within Switzerland and in several other countries, including in East and North West Africa, China, Italy, Germany and the United Kingdom. Research focuses included the sedimentology and stable isotope and trace element chemistry of lake deposits and surface waters, the paleoecology of the lakes and their catchments, paleoclimatic reconstructions from geological core and geochemical data, and the calibration of geochemical data based on current meteorological parameters. A very large number of publications arose from these studies, with those involving Guy as an author shown at the end of this article. On a day-to-day basis at ETH Guy also supervised the sedimentology and drilling core laboratories, designed, developed and maintained new sediment and water sampling equipment, and helped with the teaching and supervision of research students associated with the limno-geological group.

Unfortunately, during the mid- to late 1990s some retirements and staff changes and restructuring of research directions in the Geological Institute at ETH impacted on Guy and his position became untenable. Wanting to remain in Switzerland, he shifted completely out of lacustrine geoscientific work into largely administrative and database roles at ETH that involved 50% of his time in the Department of Biology and 50% in the ETH Alumni Office. In Zürich, Guy maintained his long-held passion for British vehicles, owning two Triumph motorcycles, including his favourite, a 1965 GT Thunderbird, and two older MG sports cars.

Despite living in Switzerland for over 40 years, and taking out Swiss citizenship in 2015, Guy continued to hold his New Zealand

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passport and to visit annually. Typically, during the Australasian summer months, Guy would return to his Waimarama home-base in Hawke's Bay for a well-earned vacation, and to allow him to check out his garaged motorbike and Jaguar cars, to attend to various personal business and financial matters, and to travel and catch up with friends and family further afield in both New Zealand and Australia. In more recent years I came to anticipate a summer phone call from Guy, with his very distinctive deep, cultured voice, and we would chat about events of the past year and sometimes meet for a few days of touring and sightseeing. His long-term plan had been to return to New Zealand to live following retirement.

However, in 2011, the year Guy retired, health problems arose. He was diagnosed with an expanding aorta that eventually led to surgery and insertion of a new heart valve. In 2013, while in New Zealand, he had a bad motorbike accident in Havelock North. He was flown to Auckland for major surgery and spent over three months recovering in Hawke's Bay before being able to return to Switzerland. Then, in 2016, following a routine blood test, it was discovered that he had a rare blood cancer, Myelodysplastic Syndrome (MDS), that required ongoing therapies. In the years since, this complicated his annual return trips to New Zealand, but special arrangements for appropriate short-term treatment in New Zealand were organised through Swiss health authorities.

Guy's last trip back to New Zealand, with his partner Brigitte Cuperus whom he met during his time at the ETH Alumni Office, was during the 2019/20 summer. Over several years Brigitte was a tremendous support and travel companion to Guy. During his retirement years, Guy returned in earnest to a long-held interest of researching in depth and writing up in three volumes his family history back to the 18th century from library, archival, hobby historian and personal UK travel sources.

Through 2020, while the world was becoming increasingly exposed to the Covid-19 virus, Guy bravely carried on the relentless battle against his cancer, a battle sadly lost at dawn on a fine wintery morning in Zürich on 2 February 2021. A small tribute ceremony for Guy will take place with Swiss friends at a beautiful nature reserve at Lake Greifen on his birthday on 28 June 2021, a fitting locality given Guy's long association with water and lakes. It is anticipated that Guy's ashes will be brought back to New Zealand where his brother Terry and family plan to arrange a Kiwi memorial service in Hawke's Bay, possibly in February 2022.

I acknowledge and really appreciate the generous help provided by Brigitte Cuperus (Zürich) during the preparation of this obituary. ■

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