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Auckland volcanoes

Otago University outreach

clean water

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A forum for the exchange of views on science and science policy

Editor: Allen Petrey
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Contents

Cover: Motukorea Island, which shows both tuff ring, scoria cone, and some minor lava flows.
Photo taken from Hayward *et al.* (2011) accredited to Alastair Jameson

Instructions to Authors

New Zealand Science Review provides a forum for the discussion of science policy. It also covers science education, science planning, and freedom of information. It is aimed at scientists, decision makers, and the interested public. Readability and absence of jargon are essential.

Manuscripts on the above topics are welcome, and should be emailed to the editor (editor@scientists.org.nz).

As well as full papers, short contributions, reports on new developments and conferences, and reviews of books, all in the general areas of interest detailed above, are invited. The journal may also accept reviews of a general nature and research reports.

Full manuscripts (with author's name removed) will be sent for peer review, and authors will be sent copies of the reviewer's comments and a decision on publication. Manuscripts should not normally have appeared in print elsewhere, but already published results discussed in the different, special context of the journal will be considered.

Manuscripts should be accompanied by biographies of not more than 100 words on each author's personal history and current interests. Authors are also expected to supply a suitable high-definition passport-size photograph of themselves. This will be published with the article.

Articles may be submitted in MS Office Word, rich text format, or plain text. Diagrams and photographs should be on separate files (preferably eps, tif, jpg, at 300 dpi), not embedded in the text.

All tables and illustrations should be numbered separately – Tables 1, 2, 3, 4, etc., and Figures 1, 2, 3, 4, etc. – and be referred to in the text. Footnotes should be eliminated as far as possible. Diagrams and photographs will be printed in black and white, so symbols should be readily distinguishable without colour, and hatching should be used rather than block shading. However, colour may be used if the author or the author's institute is willing to pay for the added cost.

References should preferably be cited by the author–date (Harvard) system as described in the Lincoln University Press *Write Edit Print: Style Manual for Aotearoa New Zealand* (1997), which is also used as the standard for other editorial conventions. This system entails citing each author's surname and the year of publication in the text and an alphabetical listing of all authors cited at the end. Alternative systems may be acceptable provided that they are used accurately and consistently.

In this issue

In the issue, postdoctoral researcher Jenni Hopkins gives a detailed description of the Auckland volcanic field (AVF). It is made up of lots of individual volcanoes that generally only erupt once, and are hence called 'monogenetic'. Globally, monogenetic volcanic fields are poorly understood, and whilst these little single eruptions may seem less threatening to human life than a large imposing volcano like Mt Ruapehu or Mt Taranaki, the frightening thing is that the location of the next eruption is completely unknown. When you couple this unknown with a large urban population and nationally dependent infrastructure, the potential threat to humans of a future eruption dramatically increases. As Jenni explains in her article, in order to reduce the unknowns, reconstructing the past eruptive history of the entire field can uncover patterns or trends in eruptions and thus allow better-informed predictions about future eruptions.

Service to the community is one of the three major goals of New Zealand's universities. The University of Otago has been taking science to the community for over thirty years. Over that time, strong programmes of outreach to school students and the general public have developed. School programmes, such as Hands-on Science, Science Wānanga and the Advanced School Sciences Academy, present science in accessible and exciting ways and encourage careers in science. The paper by Otago University's Jean Fleming, Steve Broni, Sandra Copeland, Davina Hunt and Rose Newburn outlines the history of science outreach at the University of Otago.

Philip Yock and Nicola Gaston review two recently published books.

Philip reviews the biography of Enrico Fermi by husband and wife team Gino Segrè and Bettina Hoerlin. Fermi was one of the towering figures of twentieth century physics and often considered the last person to have known all of physics. Not for him the title 'theoretical physicist', or 'experimentalist' – his realm was physics.

Nicola reviews Alice Galletly's *How to have a beer*, a recent book in Awa Press Ginger Series which is themed around the idea of introducing 'how to …'. As Nicola says, 'I started reading… out of simple curiosity, sparked in part by the apparent novelty of a woman daring to flaunt her credentials as a beer expert in public, but went away musing on how interesting it is to see scientific knowledge being communicated in such a low key, but generally useful way. It's a fun read.'

Registrations are now open for both the NZAS Annual Conference 2017 – Beyond the Usual Suspects: NZ Science at Large – to be held Wednesday 21 June 2017, 9 am to 7 pm at the Royal Society in Wellington (www.eventbrite.co.nz/e/the-new-zealand-association-of-scientists-annual-conference-registration-32944768690) and Celebrating Female Scientists – AWIS2017 on 13–14 July at the Heritage Hotel in Auckland at http://www.scienceevents.co.nz/awis2017

Finally, *vale* Dora Suuring, Dutch resistance fighter, chemist, lecturer, teacher and NZAS council member who died in March this year aged 102. Dora joined the Council of New Zealand Association of Scientists in 1979, at the invitation of John Offenberger, who was Vice-President of the Association at the time. She served on Council for 11 years, acting as Secretary for three of these.

Allen Petrey
Editor

President's column

Science is global. It matters locally what happens internationally – especially in nations we are strategically aligned with socio-economically. A few weeks ago I attended the Australian Science Meets Parliament[1] where around 200 scientists sign up to meet with politicians. While they miss out on the architectural charms of the Beehive, the two-day event involves pitching ideas, science peer-networking and generally seeing how Parliament operates. But perhaps as importantly, it puts science on the agenda for politicians in a broad-brush sense rather than fire-fighting a single issue. For a month prior, the streets of Canberra were lined with promotional flags saying 'Science'.

With a recently signed Science and Innovation cooperative agreement spanning the Tasman[2], it is time for us in New Zealand to up our game in how science and politics interact. We have a Speaker's Forum where a select group of invitees get to meet and hear some talks. This has appealing facets but it has no public profile. It takes some skilful googling to even find out about what's on. New Zealand science needs more than this. At this point in time, how politicians address science and interact with scientists is pretty front-and-centre globally. In the face of things like: dismantling the US Environmental Protection Agency; our previous Prime Minister dismissing science as something where you shopped around for the desired answer[3]; and more recently, politics and science meeting around the debate over swimmable rivers, where science turned out to be either 'junk' or the truth[4] – we need a greater understanding of science in our political corridors.

History judges these decisions and the politicians that make them – as long as we have the science to know, and the will to care. But it is more than reputation at stake. The 'Dunedin Study', based at the University of Otago, looking at long-term health trajectories, has recently revealed the impacts of a lead-soaked world of the 1970s and 1980s, showing that it actually impacted the cognitive abilities of a generation[5]. Geoff Gregory's NZAS history for 1974–1991[6] details how initiatives to reduce lead were held back for a decade against scientific advice by political machinations – shame on them! How will today's decisions that fly in the face of evidence fare in decades to come?

Nothing will change if voters and the wider public don't care about, or understand, science. Because of this, this year's NZAS Conference takes a slightly different tack to the recent past. We look at science at large in New Zealand. We may not always see them as such, but scientists are all around us, in our schools, boardrooms, our kitchens and on our farms. Their contributions can be found in our government, media, art galleries, and our imagination. If you've ever wondered where the science you learned at school has gone or where it could take you, then join us on June the 21st to look beyond the usual suspects and explore the world of New Zealand science at large. We'll be web streaming and archiving the talks for everyone to see.

We decided on the conference theme pre-Brexit, pre-Trump and before a politician held up a lump of coal in the Australian Federal Parliament to tell us how harmless it is while unprecedented heat waves roared across the country. Not wanting to go on about our prescience – but there's never been a more important time to understand the role science and knowledge plays in our societies, to understand the connections between science, belief and faith.

Unlike the warming-induced increased likelihood of extreme weather, there's little we can do about volcanic eruptions except early detection and workable response plans. In this issue of the *New Zealand Science Review*, Jenni Hopkins describes the complex volcano beneath New Zealand's largest city. The issue also contains an article focusing on the science communication achievements from the other end of the country. Jean Fleming, our 2016 Science Communicator medallist, leads an article on three decades of science outreach. There has never been a more important time to communicate science to all audiences, in any way that works.

Craig Stevens
President

[1] https://scienceandtechnologyaustralia.org.au/what-we-do/science-meets-parliament/

[2] https://www.beehive.govt.nz/release/australia-new-zealand-science-and-innovation-agreement-signed

[3] BBC Hardtalk, Broadcast 9 May 2011. news.bbc.co.uk/2/hi/programmes/hardtalk/9480610.stm

[4] http://www.radionz.co.nz/news/political/325235/water-quality-criticism-based-on-%27junk-science%27-smith

[5] Reuben et al. *JAMA*. 2017;317(12):1244–1251. doi:10.1001/jama.2017.1712

[6] *NZ Science Review* 2014, vol 71(4): p. 89.

Shining a light on Auckland's volcanic monster under the bed

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If you asked a person to draw a volcano, generally they would draw a triangle shape, not unlike Mt Taranaki, with either steam coming out of the top, or lava flowing down the sides. What they would not draw is lots of little apparent hills and lakes, but this is what Auckland's volcanoes are like. The Auckland volcanic field (AVF) is made up of lots of individual volcanoes that generally only erupt once, and are hence called 'monogenetic'. Globally, monogenetic volcanic fields are poorly understood, and whilst these little single eruptions may seem less threatening to human life than a large imposing volcano like Mt Ruapehu or Mt Taranaki, the frightening thing is that the location of the next eruption is completely unknown. When you couple this unknown with a large urban population and nationally dependent infrastructure, the potential threat to humans of a future eruption dramatically increases. In order to reduce the unknowns, reconstructing the past eruptive history of the entire field can allow patterns or trends in eruptions to be uncovered, and allow better-informed predictions about a future eruption to be made.

Background

Monogenetic volcanic fields exist globally, exhibiting a range of characteristics. Individual eruptions are relatively small scale (usually 0.0001 to 4 km^3; Guilbaud *et al*. 2012), leading to eruptions that may only last from a few days to months (Connor & Conway 2000). As a result of this, the magma ascent pathways do not remain a favoured route for continued activity, and subsequent eruptions occur in isolation from the previous vent site. Volcanic fields generally contain 10–100 vent sites (Connor & Conway 2000), with the current count in the AVF at 53 centres covering an area of 360 km^2 (Hayward *et al*. 2011; Fig 1). However, some fields can be considerably larger, for example the Michoacán-Guanajuato field in Mexico, contains evidence for over 1000 eruptions and covers >40,000 km^2 (Connor 1990). In comparison to other volcanic systems, monogenetic eruptions have a very low magmatic output, but cumulatively a field's total eruptive products can be comparable to polygenetic systems (Németh 2010). The lifespan and productivity of volcanic fields is also highly variable. For example, the 53 centres of the AVF have erupted over the last c. 200,000 years. In comparison, Cima volcanic field, California, has approximately 70 centres formed over the last 4.5 million years (Dohrenwend *et al*. 1986). Eruptive activity is, however, rarely constant, with periods of heightened activity and periods of quiescence, commonly identified where full field studies have been undertaken (e.g. Leonard, G. pers. comm.).

Most commonly monogenetic fields are found within intraplate settings (away from plate boundaries) with basaltic products, like the AVF (Valentine & Gregg 2008). However, fields are found linked to subduction-related upwelling (e.g. Ortega-Gutiérrez *et al*. 2014) to plume-like rifting environments (e.g. Shaw 2004), with siliceous andesitic to rhyolitic complexes identified (Tanaka *et al*. 1986). Despite variability in the geological settings, there appears to be a common relationship between the local structural environment and the orientation of monogenetic centres. For example, individual centres can be located along known fault lines (e.g. Springerville Volcanic field, Arizona; Condit & Connor 1969), or can migrate relative to plate movements (e.g. San Francisco Volcanic field, Arizona; Tanaka *et al*. 1986). Another commonality at the global scale is the eruptive products that form as a result of the interaction between the upwelling magma and local water (ground or surface). If there is interaction with water, the eruption will be explosive (phreatomagmatic), likely leading to pyroclastic density surges (e.g. Brand *et al*. 2014), ash fall (e.g. Hopkins *et al*. 2015), and the production of a maar-diatreme crater and tuff ring (e.g. Fig 2A). In comparison, if the ascending magma does not encounter water, a dry eruption will ensue, comprising fire fountaining and the production of a scoria cone and lava flows (e.g. Fig 2B-C; Hayward *et al*. 2011). In the AVF, individual centres generally show evidence of a progression from explosive wet eruptions to effusive dry eruptions, as any surface water is used up before cone building ensues.

The AVF is not unusual in its location close to a high-density urban population (e.g. Michoacán-Guanajuato in Mexico City; or Harrat Rahat, Al-Madinah in Saudi Arabia), and therefore more recent studies have begun to focus on the hazard and risk implications of a future eruption scenario. Unlike with a polygenetic cone, where the source vent of the next eruption is obvious, monogenetic eruptions are much harder to predict because of the unknown location of a future vent. Investigations have therefore focussed on reconstructing the eruption history of

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Jenni Hopkins is a Postdoctoral Researcher currently working in collaboration with GNS Science, the DEVORA project, and Victoria University of Wellington. Originally from England, Jenni came to Wellington after completing an MSc in geochemistry to undertake a PhD in geochemical volcanology in 2011. Her thesis focused on reconstructing the evolution of the Auckland Volcanic Field through developing new geochemical correlation techniques in tephrochronology. Her current research is focussed on further developing geochemical and radiometric dating techniques on New Zealand ash deposits, with application to hazard and risk management strategies in the event of future eruption scenarios.

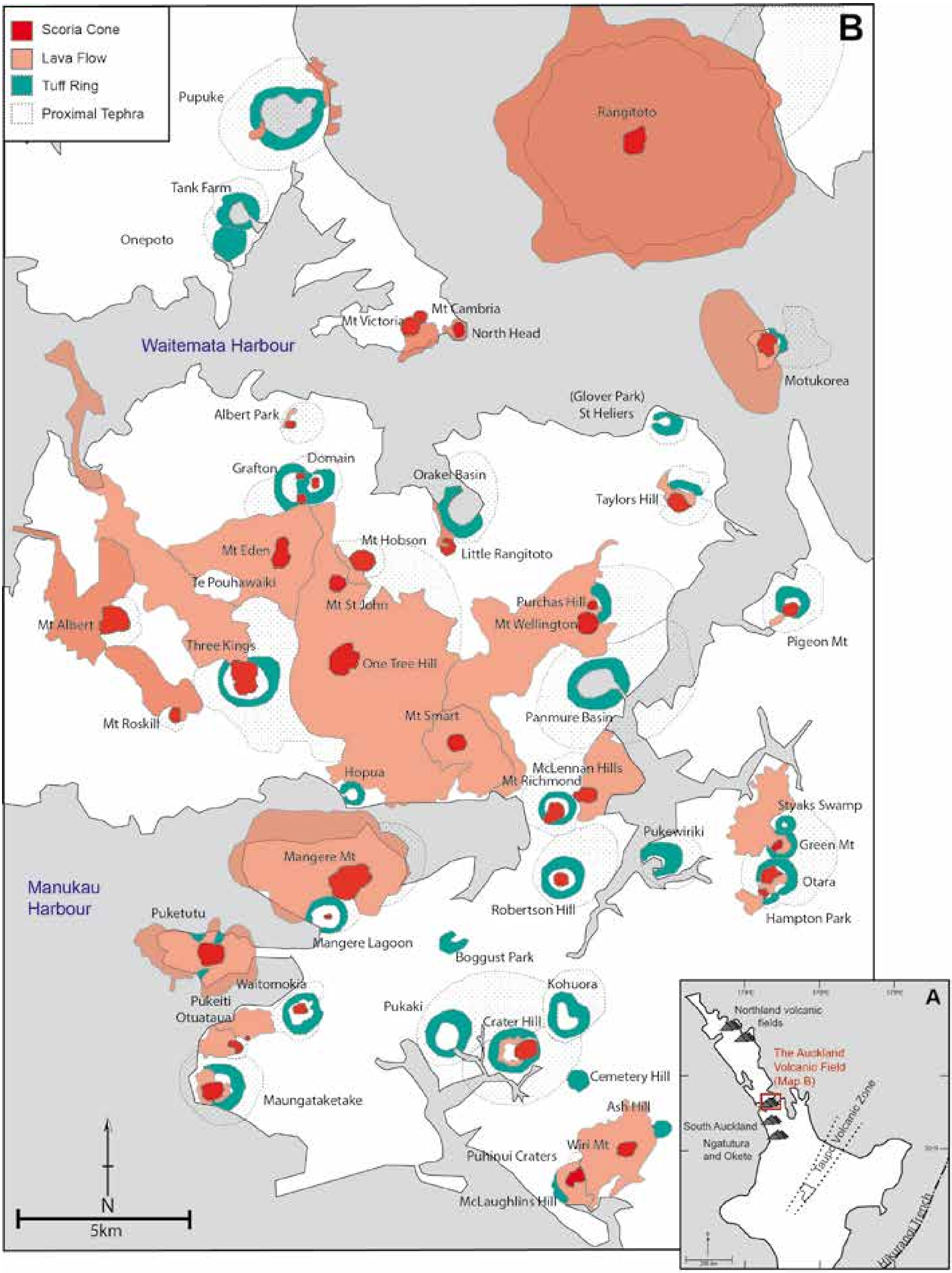

Figure 1. A. Location of the AVF, New Zealand; included are other monogenetic volcanic fields also found on the North Island. B. Location of the centres of the AVF, and their key physical characteristics.

Figure 2. Examples of the differing volcanic landforms seen in the AVF: (A) The maar crater and tuff ring of Orakei Basin created through explosive wet eruptions; (B) the scoria cone of Mt Eden created through dry eruptions; and (C) Motukorea Island which shows both tuff ring, scoria cone, and some minor lava flows. Pictures taken from Hayward *et al.* (2011) accredited to Alastair Jameson.

monogenetic fields in order to find patterns in vent distribution, recurrence rates and geochemical signatures. For Auckland, the DEVORA project (Determining Volcanic Risk in Auckland) was set up in 2008 to do just this, and as a result the AVF is now one of the best studied volcanic fields globally.

AVF specifics

AVF is actually the youngest in a series of intraplate volcanic fields that run along the west coast of the North Island, New Zealand (Fig. 1A). Okete is the southernmost and oldest field (2.69–1.8 Ma; Briggs *et al.* 1994), followed by Ngatutura (1.83–1.54 Ma; Briggs et al. 1994), South Auckland volcanic field (SAVF) (1.59-0.51 Ma; Cook et al. 2004), and finally Auckland volcanic field (Fig 1). Based on the characteristics of the AVF compared with the South Auckland VF, which has approximately 98 centres erupted over about 1 million years (Cook *et al*. 2004), some authors have suggested that the AVF is still in its eruptive infancy (e.g. Hayward *et al*. 2011).

Current data suggest the total output from the field is about 1.7 km^3, just under half of which is linked to the eruption(s) of Rangitoto (Kereszturi *et al*. 2013). These volumes are relatively small when compared to cumulative eruptive volumes of some of the other volcanoes in New Zealand (e.g. Ruapehu ~ 110 km^3, Gamble *et al*. 2003; or the largest eruption from Taupo, the Oruanui, ~ 1170 km^3, Wilson 2001). In the AVF the erupted volumes have recently been linked back to the original mantle source characteristics (McGee *et al*. 2013). These characteristics can be understood using the geochemistry of the erupted products. Recent work by Lucy McGee and co-authors highlighted that many of the centres showed slightly differing geochemical signatures, especially within their trace element compositions. They concluded that the variations observed in the eruptive products were reflective of the mixing of three different mantle sources, each with differing geochemical signatures, and, as a result it was suggested that each centre had the potential to have a unique geochemical signature, with varying magma volumes. A connection was therefore made between mantle source, the size of the magma body formed, and the eruption style at the surface.

Morphostratigraphic constraints (for example, where ash or lava from one eruption is found overlapping another) allow the relative ordering of some volcanoes to be determined, but these relationships are not prevalent across the field, and a full field order cannot be reconstructed in this manner. Radiometric techniques have been used with varying success in the AVF. In 2011, a review of the ages of each individual eruption concluded that of the 53 centres, only three (Rangitoto, Mt Wellington, and Three Kings) were 'reliably and accurately dated', with a further eight 'reasonably reliably dated' (Lindsay *et al*. 2011). This lack of understanding of the eruption order and repose periods (time between eruptions) significantly reduces our ability to forecast future eruptions. A recent study combines improved methodologies in $^{40}Ar/^{39}Ar$ techniques in order to report new ages for an additional 23 centres (Leonard, G. pers. comm.). However, uncertainties associated with these radiometric techniques (e.g. $^{40}Ar/^{39}Ar$ analysis) make them unable to resolve the small repose periods for the eruptions of the AVF (Fig 3). For example, where multiple eruptions have overlapping ages, neither their relative nor their absolute eruption order can be identified.

Tephrochronology and its applications

Tephrochronology is a stratigraphic method that uses tephra deposits to synchronise, date and link geological events, for example individual volcanic eruptions (Lowe 2011). The term 'tephra' relates to all unconsolidated, explosively erupted material of all grain sizes, whereas 'ash' refers to a size fraction of this material <2 mm in diameter.

The maar craters that form from phreatomagmatic eruptions (e.g. Fig 2A) not only preserve the eruption and provide evidence of the centre itself, but also provide a depositional environment for tephra deposits from the surrounding successive eruptions. In addition, because the deposits are layered within the lake sediments they provide a mostly well-preserved relative order of eruptive events.

The basaltic tephras are punctuated with well-correlated and dated rhyolitic tephras from eruptions in the central North Island, e.g. from Taupo. These rhyolitic deposits give absolute age constraints to the ages of the intervening basaltic deposit (e.g. Molloy *et al*. 2009). The rhyolitic ages also allow sedimentation rate estimates to be calculated. These sedimentation rates can then be used to assign approximate ages to the basaltic tephra deposits themselves.

Prior to our work, the basaltic tephra deposits from the AVF had not been used to their full potential, their sources were unknown, and therefore their usefulness in reconstructing the eruptive history of the field's centres was limited. The aim of our work was therefore to develop a method to link the proximal tephra deposits found within the maars back to their source centres. This would allow the relative and absolute ages for the AVF eruptions to be resolved.

In order to collect the tephra samples from within the maar lakes, long sediment cores were retrieved (typically between 30 and 80 m long). In many cases these cores drill down to where the lacustrine sediments end and where dense volcanic deposits are found, indicating the volcanic crater itself has been reached. From the length of the core, we could therefore estimate the age of the centre, as well as the tephra horizons preserved within it. Our improved methodology began at the initial analysis of the cores themselves.

Dark coloured basaltic tephra deposits, especially when they are particularly fine-grained, are very difficult to identify through visual observation alone. We therefore exploited their geochemical properties in order to make their identification much easier. Products of basaltic eruptions will generally have a higher proportion of magnetic minerals (e.g. Mg, Fe) and be slightly denser, in comparison to the lake sediments. Therefore, if the magnetic susceptibility of the core is measured, the basaltic horizons will general show a spike in the readings, and in addition, an X-ray density scan of the core will reveal the basaltic tephra horizons as much lighter in colour on an X-ray (e.g. Fig 4; Hopkins *et al*. 2015). This method of core analysis highlighted even the thinnest of basaltic horizons, and in addition allowed us to identify areas of reworked tephra within the core, allowing just the primary deposits to be taken into account for our reconstructions.

Geochemical analysis of the tephra horizons showed that each one had a relatively distinct signature and could therefore be geochemically fingerprinted. This allowed our team to accurately correlate the tephra deposits across 6 different cores (from north to south in Fig. 1: Pupuke, Onepoto, Glover Park, Orakei, Hopua, and Pukaki centres), covering an estimated age range from the present to approximately 200,000 years ago. Once the tephra horizon chronology was developed, the next challenge was to work out how to accurately correlate these tephra deposits to their source centres.

In traditional tephrochronology, the geochemistry of the distal tephra deposits (far from source) are linked to their proximal (near source) counterparts. However, in Auckland there are minimal proximal tephra deposits and often lots of potential source centres. As a result, linking even proximal tephra deposits to their source is difficult, and therefore linking distal to proximal tephra to find the origin of the distal tephra is practically impossible. We therefore developed a new method to correlate the distal tephra to the proximal whole rock deposits (e.g. lava or scoria), because proximal whole rock deposits are much more easily linked to their source, and are a lot more common in the AVF. This method exploited the geochemical variance in the deposits of the AVF but also used age, locational, and volumetric constraints to allow the tephra horizons to be accurately correlated. Of the 29 tephra horizons found within the AVF cores, 26 were correlated to a source centre. The outcome of these correlations not only allowed the relative eruption history of 48 of the 53 centres to be put in order, but also allowed the tephra dispersal patterns of the AVF eruptions to be rationalised.

Key research outcomes

The reconstruction of the relative and absolute eruption order of the AVF highlights some patterns within the temporal spacing of the eruptions. Our current understanding indicates Pupuke was the first eruption, occurring between 190,000 and 200,000 years ago. From this point until around 50,000 years ago, another 18 centres erupted, with an average repose period during this time of around 8000 years. The remaining centres erupted

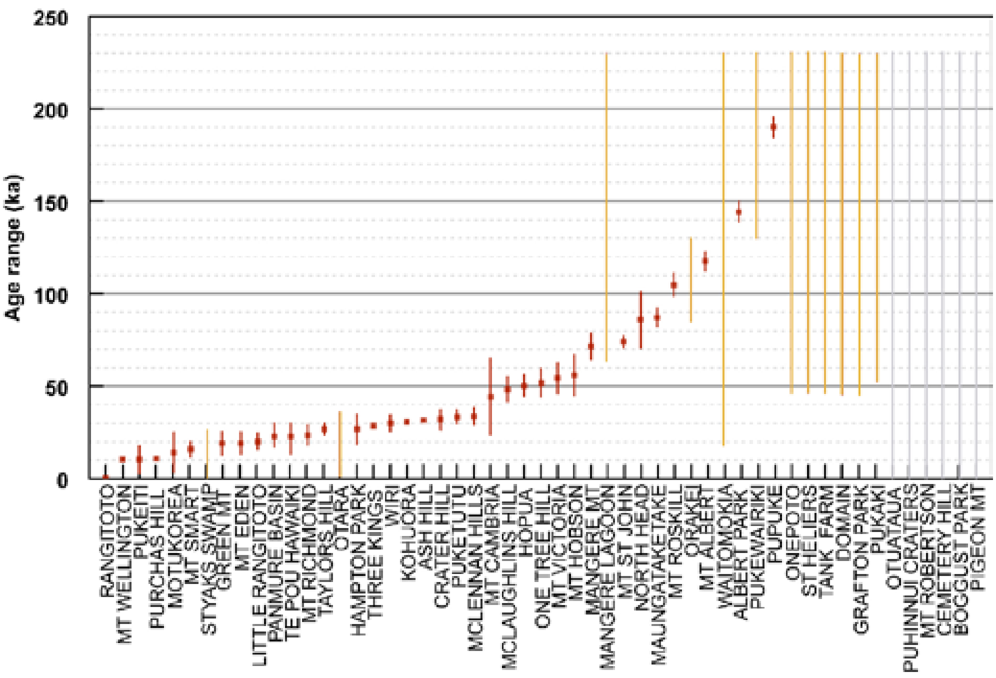

Figure 3. Proposed ages for the centres of the AVF. Those in red are $^{40}Ar/^{39}Ar$ (from Leonard, G. pers. comm.) or ^{14}C ages (from Cassata *et al.* 2008 and Lindsay *et al.* 2011) with their mean ages shown by the markers and the errors on these ages shown by the lines. Those in orange have their ages based only on morphostratigraphy, and those in grey have no ages associated with them. Of note is the number of centres which, based on errors, could have erupted at a given time, for example at 50 ka: there are 18 potential centres (Mt Cambria, McLaughlins Hill, Hopua, One Tree Hill, Mt Victoria, Mt Hobson, Waitomokia, Onepoto, St Heliers, Tank Farm, Domain, Grafton, Otuataua, Puhinui Craters, Mt Robertson, Cemetery Hill, Boggust Park, and Pigeon Mt) whose age ranges include 50 ka.

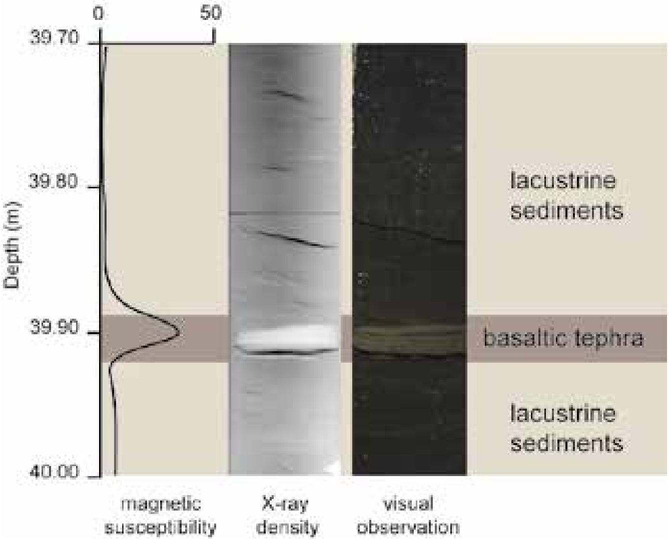

Figure 4. An example of a typical basaltic horizon exhibiting a sharp peak in magnetic susceptibility (SI units) and the bright contrast of the horizons on the X-ray density scan, in comparison to the 'background' lacustrine sediments (adapted from Hopkins *et al.* 2015).

between 50,000 years ago and the present, with an average repose period of 1400 years. The average repose periods are helpful in highlighting an increase in eruption rate from 50,000 years ago to the present, but they also mask some of the finer detail relating the eruption timings. For example, within both these time windows (200,000 to 50,000 years ago, and 50,000 years ago to present) there are repose periods of less than 500 years. From these results we have highlighted evidence for increasing activity to the present, an interesting and important outcome in relation to hazard and risk mitigation.

In addition to eruption timings, the evolution of the dispersal pattern for the AVF eruptions has also now been addressed. The results from this study indicate a large variation in distances between successive eruptions, in general varying from < 0.5 km to 14 km in distance. As detailed by previous studies, some vents do show alignments linked to near-surface faults (e.g. Kenny *et al*. 2011; Kereszturi *et al*. 2014), but in general there is no spatial progression or pattern to vent location through time, and therefore a definitive future vent site remains an unknown.

Correlation of tephra deposits both between core sites across the Auckland region and to their source centre allows estimations of tephra dispersal patterns to be characterised. Of the 29 tephra horizons found within the cores, 17 were only found in a single site location, indicating that for a large number of eruptions the tephra dispersal was limited. This suggests that in the event of a future eruption the entire city may not be affected. However, for some of the larger eruptions, for example One Tree Hill, Mt Eden, or Three Kings, the tephra was dispersed across the entire field, from Pukaki in the south to Pupuke in the north (Fig. 5). For some of these larger eruptions, deposits > 10 cm thick were identified at < 6 km from the vent. These results support previous research indicating that dangerous pyroclastic density currents will affect the proximal vent area in the case of phreatomagmatic eruptions (Brand *et al*. 2014). The results also indicate that tephra shard size decreases away from the vent, an important additional health implication when considering evacuation planning and risk management for areas not directly affected. For example research shows that smaller size fractions of ash can be more hazardous than larger size fractions as they can enter the respiratory system, causing acute and chronic respiratory diseases (e.g. Horwell 2007).

Tephra fall is considered to be one of the most likely and potentially most costly of the volcanic hazards to impact Auckland, causing disruption to transport systems, contaminating water supplies, damaging buildings, and being hazardous to

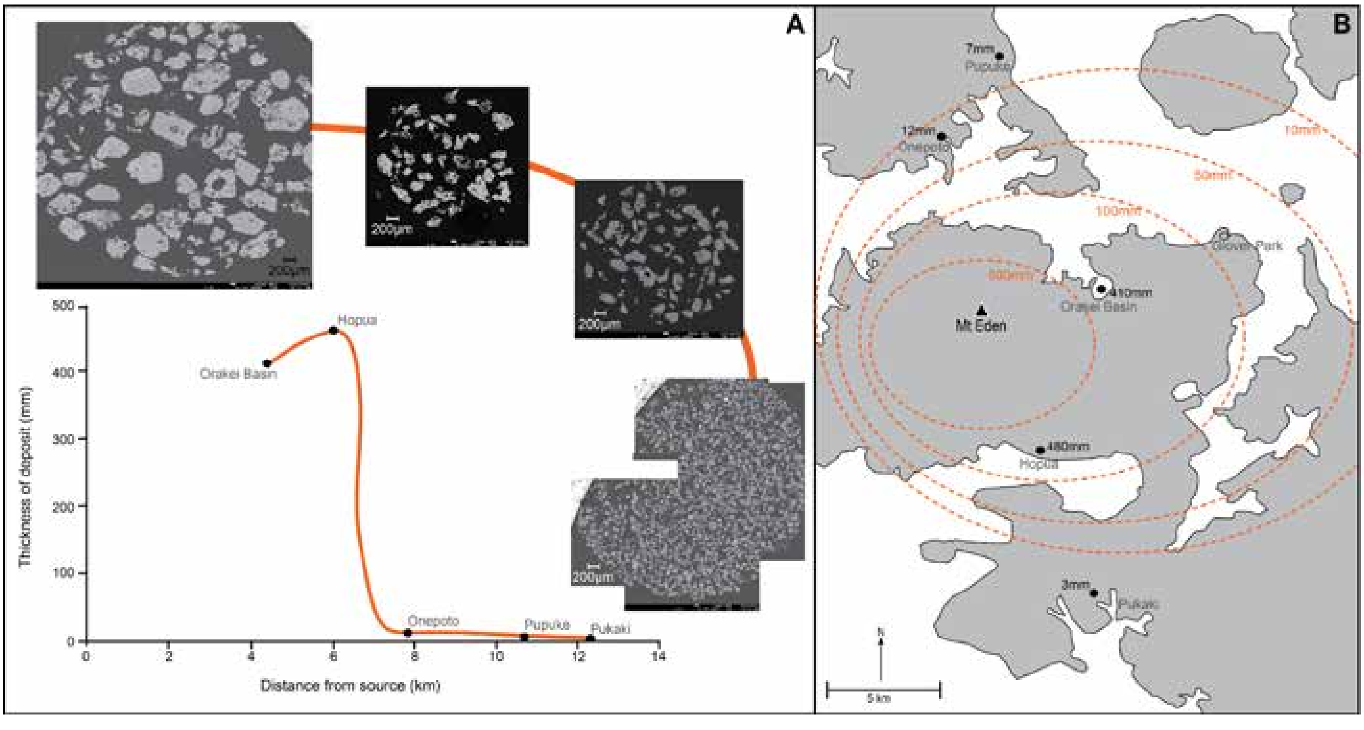

Figure 5. Example of the correlation of Mt Eden eruption to tephra deposits across the AVF: (A) Change in deposit thickness away from source. Note the extreme decline in thickness after c. 6 km distance. Also shown are backscatter electron images of the shards from each core site taken on electron microprobe (EMPA). All pictures are at the same scale with the bar at the base of the images representing 200 µm. (B) Inferred isopach map of the tephra dispersal from Mt Eden, based on the deposit thicknesses found in the cores. Dispersal is skewed to the east to reflect the westerly winds likely to have been present at the time of eruption (Hayward *et al.* 2011).

human health (Hayes *et al*. 2015). This scientific research is a highly important input into modelling eruption scenarios in order to define potential outcomes, and thus inform hazard and risk management plans. Teams at both GNS Science and Massey University are currently developing hazard and risk models as part of the DEVORA project. RiskScape, a multi-hazard risk assessment tool has been developed and expanded to evaluate the proximal volcanic hazards likely to affect Auckland (Deligne *et al*. 2015). Multiple hypothetical eruption scenarios have been modelled in order to account for a variety of eruption characteristics. For example, the outcomes of eruptions occurring through differing substrates, in differing locations (e.g. city, airport, residential) and at differing volumes can be evaluated. The impacts to infrastructure can be identified before, during, and after an eruption, and the long-term impacts of an eruption can be modelled (Deligne *et al*. 2015).

Predicting when and where the next volcanic eruption from Auckland will occur is certainly not an easy task. Over the course of the DEVORA project to date, the scientific gains made by many multidisciplinary scientists are an invaluable input into the planning and prediction for future eruption scenarios. We now have a much better grasp on many of the characteristics and are able to use this knowledge to model the potential outcomes from an eruption, and the impacts on the people of Auckland, the infrastructure, and the economy.

Acknowledgements

Elaine Smid and Natalia Deligne are thanked for their input into the formation of this article. Jenni's research is funded by the DEVORA project, which is led and managed by Jan Lindsay (University of Auckland) and Graham Leonard (GNS Science).

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Glossary

andesite/andesitic – volcanic rock (or lava) containing 54% to 62% silica and moderate amounts of iron and magnesium. High silica content characterises siliceous andesite.

^{40}Ar/^{39}Ar (argon-40/argon-39) dating – a variation of potassium–argon dating, in which the concentration of stable ^{40}Ar, created from radioactive 40K in a reactor, is compared with the concentration of stable ^{39}Ar.

ash – fine particles smaller than 2 mm in diameter of pulverised rock (tephra) erupted from the vent of a volcano.

basalt/basaltic – volcanic rock (or lava) containing less than 54% silica, commonly producing more effusive, runny and less explosive lava.

diatreme – a long vertical pipe or plug formed when gas-filled magma forced its way up through overlying strata.

intraplate volcanism – volcanic activity that occurs within tectonic plates and is generally not related to plate boundaries and plate movements.

isopach – a line on a map connecting points below which a particular rock stratum has the same thickness.

ka – thousands of years ago.

Ma – millions of years ago.

maar – a volcanic crater formed by a phreatomagmatic eruption. Typically the eruption occurs in a wet or low-lying area. These craters are often wide, but shallow.

morphostratigraphic – organisation of rock or sediment strata into units based on their surface morphology (landforms).

monogenetic volcanic field – a field of individual volcanoes each of which generally only erupts once.

phreatomagmatic – an explosive volcanic eruption that results from the sudden interaction of surface or subsurface water and magma.

polygenetic volcanic field – a group of polygenetic volcanoes, each of which erupts repeatedly.

pyroclastic surge, or base surge – an extremely fast turbulent horizontal flow of a hot fluid mixture of rocks, tephra, gas and steam from the base of an eruption column.

radiometric dating – a method for determining the age of geological materials using radioactive isotopes.

rhyolite/rhyolitic – volcanic rock or highly viscous magma, with a high silica content (typically more than 69%), found as pumice, ignimbrite, or obsidian.

scoria cone – a small volcanic hill formed mainly of scoria (a frothy basaltic rock) erupted from a central vent.

siliceous – pertaining to silica content; basalt is poor in silica and is very hot and flows freely, while rhyolite is rich in silica, is cooler and more viscous.

subduction zone – where two tectonic plates meet, with one moving down into the mantle.

tephra – solid material of all types and sizes erupted from a volcanic vent and that travel through the air.

tephrochronology – a stratigraphic method that uses tephra deposits to date and link geological events.

tuff – a light, porous rock formed by consolidation of volcanic ash.

Article

Thirty years of science outreach at the University of Otago

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Abstract

Service to the community is one of the three major goals of New Zealand's universities, the others being advancement of knowledge through research and higher education through teaching. The University of Otago has been taking science to the community for over thirty years. Over that time, strong programmes of outreach to school students and the general public have developed. School programmes, such as Hands-on Science, Science Wānanga and the Advanced School Sciences Academy, present science in accessible and exciting ways and encourage careers in science. This paper outlines the history of science outreach at the University of Otago.

Keywords: New Zealand, history of science, University of Otago, outreach, public engagement, science communication, science education, science festival

Introduction

Since the establishment of universities, the tripartite mission of advancement of knowledge through *research*, higher education through *teaching,* and *service* to those beyond the university, have been core goals. Over a decade ago, Bryne went so far as to predict 'engagement with others will not be an option for universities of tomorrow… it will be a defining characteristic' (Bryne 2000). The history of community engagement by the University of Otago began in the 1970s with community education through the Otago University Extension Office, including science extension activities run in schools and as on-campus holiday camps (Clarke 2014). Public engagement with science at the University of Otago began in earnest in the mid to late 1980s, with a flurry of activities, including a science quiz and a Maths competition, that continue to operate today (Zega 2012).

Hands-On Science

In 1989, Gerry Carrington (Physics Department), Warren Featherston (Zoology), Shirley Milward (Holiday Seminars for the Gifted and Talented), Mike Paulin (Zoology), and Kath Rice (Head of Science at Otago Girls High School) established a science camp for secondary students of exceptional ability (Otago Science Education Forum 1990). The group primarily

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Jean Fleming is a Professor Emerita in Science Communication, having retired after six years at the University of Otago's Centre for Science Communication. Jean is interested in effective communication of controversial scientific issues to a range of audiences, in the motivations of those who volunteer in environmental restoration projects, as well as new ways of engaging school students with science. She has a long-standing interest in outreach of science into the community and helped organise both Hands-on Science at Otago, for secondary school pupils, and the New Zealand International Science Festival in Dunedin for nearly 20 years.

Steve Broni has a BSc in Zoology (Marine Biology) from University of Glasgow and Masters in Marine Ornithology from University of Cape Town. He joined the Division of Sciences at the University of Otago in 2010 to establish the Otago University Advanced School Sciences Academy (OUASSA) Steve has a passion for science education and communication.

Sandra Copeland has worked as a secondary science teacher for many years. She has been associated with Hands-On Science (now Hands-On at Otago) since 2005, first as Camp Manager and later as Co-ordinator. Sandra has extensive experience of science education in New Zealand, and is still a teacher at heart.

Davina Hunt has a Masters in Teaching & Learning, postgraduate Diplomas in Wildlife Management and Education and a BSc(Zool.). She has been a teacher, researcher, policy advisor and facilitator of environmental education for sustainability for over 20 years in New Zealand. Davina joined the Division of Sciences in 2009 to expand the fledgling Science Wānanga programme, through partnerships with iwi and schools to enhance engagement of Māori students in science.

Rose Newburn is a freelance writer based in Dunedin. At the time of writing, she was Divisional Marketing and Communications co-ordinator for Sciences at Otago. Rose's first role at Otago was running Hands-On Science and this led to her involvement in and development of a number of interactive science programmes for the Division, working to make science learning accessible, equitable and above all engaging.

focussed on providing hands-on experiential learning to gifted and talented students. The first Hands-On Science Camp was held in January 1990, for a group of 139 students, 83 girls (60%) and 56 boys, from across New Zealand. Projects were offered in a range of Science and Health Science disciplines and the week-long programme included a wide range of social activities including a disco and a team sports challenge (Otago Science Education Forum 1990). Students stay in a university college hall and go off every morning to complete a range of research projects in around 20 science departments, including health sciences. In addition, a public lecture from an eminent scientist and a science quiz keep participants busy. The afternoons are spent in a variety of 'science snacks', allowing a glimpse of both public and academic science work. The programme culminates on the Friday morning with a public report-back session, where students in each project work together to present a 3-minute summary of their week of research.

In 2016, the new 'Hands-On at Otago' programme included Humanities and Business projects, with 355 participants. Many members of traditionally under-represented ethnic groups attended the 2016 Hands-On at Otago, with 22% Māori, 10% Pasifika, and 13% self-identified Asian attendees. Informal exit polls suggested the week developed confidence to enrol in tertiary study (Sandra Copeland & Rose Newburn, pers. comm. 2014; Zega 2012), but in addition, the experience may promote understanding of the research process (Hodder 2010).

International Science Festival

A biennial International Science Festival (NZISF) was initiated in Dunedin in 1997, by Dunedin's Deputy Mayor, Dame Elizabeth Hanan (Barnett 2010). The NZISF is a not-for-profit organisation that aims to promote and celebrate science, technology and the natural environment to a general audience, and show that science is exciting, fun, and accessible (Green 2014). The festival is well supported by the Dunedin City Council, the University of Otago and a number of commercial sponsors. The first NZISF brought in over NZ$4 million to the city and by 2000 the event injected more than NZ$5 million into the local economy (NZPA 2000).

Ticket sales and online polling suggested that over 16,600 people attended the 170 events in the 2016 festival, an increase of 8% from 2014. Over 95% of attendees surveyed experienced increased knowledge and interest in science and were likely to recommend the festival to others. In 2016, for the first time, there was a 100% positive response rate to the question 'Did you find the events interesting?' (Green 2016).

Academic and general staff at the University of Otago participate in a two-day Science Expo (Figure 1), held on campus, involving more than 30 displays, presentations, exhibits and workshops for all ages and appetites (Green 2014). The Science Expo attracts 2,500 to 3,500 people each festival, allowing direct interaction between scientists and members of the public (Strategy First 2010). The Expo also provides staff and students with an opportunity to practice effective communication of their science to the public.

Science Wānanga

In 2007, a conversation between Rose Newburn, Dr Stephen Scott and Dr Paratene Ngata (a leader in Māori health from Ngāti Porou), demonstrated the iwi's strategic imperative to increase the number of rangatahi (young Māori) achieving in science and health sciences. This led to the development of a two-day marae-based camp, sharing knowledge between Māori and non-Māori scientists and providing field and lab-based science activities to young Māori from local schools. Within four years these Science Wānanga had expanded to annual three-day, two-night experiences for seven iwi. As the programme developed, iwi and schools chose science topics of local relevance, some of which also provide a platform for on-going research for university scientists, informed by local community knowledge. This gave rise to Mātauranga Māori (traditional knowledge) being valued by scientists and science being valued by Māori communities and provided excellent learning opportunities for the attending students and their teachers (Davis 2014).

Figure 1. Professor Mark Stringer (Department of Anatomy) describes the muscles of the human body, painted on a live model, for the University of Otago Expo at the 2012 New Zealand International Science Festival.

Photograph J.S. Fleming

There have been 31 Wānanga delivered by the University of Otago and iwi partners since 2008. The programme has been cited by UNESCO (Mulà & Tilbury 2011) and the New Zealand Council for Educational Research (Bolstad et al. 2013) as an excellent example of successful community engagement. Science Wānanga are a tangible expression of the University's partnerships with iwi.

The Otago University Advanced School Sciences Academy (OUASSA)

The OUASSA programme, jointly funded by the New Zealand Ministry of Education and the University of Otago, was developed in 2011, to target potentially high-achieving science students in lower-decile, small, and rural/provincial New Zealand schools (Zega 2012). Registration and travel costs are fully funded for the OUASSA. It brings 50–60 potentially high-achieving students to Dunedin and introduces them to cutting-edge research, through practical projects held over two 5-day residential science camps. There is also a strong focus on communicating science: students present 10 min science shows at the Otago Museum at the end of the second camp. Two Professional Development Workshops for teachers are also run each year and on-line support is provided throughout the year to both student and teachers through a 'Virtual Academy'. OUASSA has had a significant positive impact on the tertiary trajectories of attendees (OUASSA Review Panel 2016).

Departmental outreach at the University of Otago

Outreach activities can be found in departments from all Divisions at Otago, including Law and Commerce (scienceoutreach.otago.ac.nz). Two examples stand out in the Division of Sciences. Since the mid-1990s, the Department of Marine Science has developed a broad range of educational programmes at the NZ Marine Studies Centre, for school groups of all ages, gifted and talented students and public demonstrations, as well as a nation-wide citizen science initiative called Marine Metre Squared (Zega 2012). The Department of Chemistry invests in outreach to intermediate pupils, using staff specifically hired for this work (Warren 2011). Chemistry has a long tradition of chemistry 'magic' shows and plays (Peake 2011). Senior Teaching Fellow Dave McMorran also runs a weekly programme on Otago Access Radio called Science Notes, where postgraduates talk about their research and play their favourite music.

Recognition for community engagement at the University of Otago

Recognition for community service has been built into the promotion process for academic staff for decades. Community engagement or outreach activity is now seen as a valid form of community service for career development purposes. The University's Strategic Direction to 2020 encourages strong external engagement of staff and support for under-represented groups in university study (Hogg 2014).

Recognition for outreach activities by non-academic or 'general' staff has been slower to arrive. Many non-academic staff are involved in community engagement, either as practitioners or as administrative support. The University's Personal Development Review process for general staff includes the competencies *Service to Customers* and *Initiative and Innovation.* General staff are now able to use these to receive recognition of their outreach activities (University of Otago 2014).

The opportunities for students to engage with communities may depend on their particular discipline. In some courses formalised engagement activities may be compulsory, and/or credit bearing, or there may be paid positions that make use of the students' area of expertise. Some activities are developed by staff and extended to students, such as the Chemistry Outreach programme; and some are student-led, such as the Orokonui Ecosanctuary initiatives led by Zoology PhD Bastian Egeter (ODT Magazine 2015).

The Science Outreach Certificate

Outreach activity by students gained recognition in 2013, with the establishment of the University of Otago Outreach Certificate (Dick 2013). Students register to complete a portfolio of community engagement of 40-60 hours of outreach activity. Students report improved communication skills, ability to work in teams, as well as better personal organisation, project planning and confidence (Hesson *et al.* 2014; Brown *et al.* 2016). Administration of the Certificate is through the Division of Sciences at Otago, but outreach hours may be completed in any of Sciences, Health Sciences, Humanities and Commerce. Since its establishment, over 70 students have signed up for the Certificate, over a wide range of disciplines (Dick 2013). The Outreach Certificate may therefore become a formal way of assessing students' abilities to engage with the public.

The future

With the development in 2013 of the National Strategic Plan for Science in Society, 'A Nation of Curious Minds - He Whenua Hiriri I Te Mahara', by the New Zealand Ministry of Business, Innovation and Employment, the scene changed for outreach activities throughout New Zealand. Now, public engagement with science was recognised and funded.

The University of Otago has responded by expanding outreach, including 'Lab in a Box' (Gibb 2015) and Hands-on Otago. The Otago Museum now houses the NZISF offices and the Perpetual Guardian Planetarium, providing more opportunities for outreach by Otago students. Outreach activities are thriving, recognised and rewarded at the University of Otago.

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Submit your entry via https://www.scanz.co.nz/award/ before 31 July 2017.

Abstract

Freshwater quality: It's not only the cows you need to watch

Swimming baths a third of the size of an Olympic pool contain around 75 litres of pee – or the volume of a small wheelie bin – according to Canadian researchers. Aside from being more than a bit gross, piddle in pools can react with chlorine and cause eye irritation and breathing problems, say the authors, L K Jmaiff Blackstock and colleagues from the Faculty of Medicine and Dentistry, University of Alberta, Canada.

More seriously ...

Sweetened swimming pools and hot tubs

Lindsay K. Jmaiff Blackstock, Wei Wang, Sai Vemula, Benjamin T. Jaeger, and Xing-Fang Li*
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Nitrogenous organics in urine can react with chlorine in swimming pools to form volatile and irritating NCl-amines. A urinary marker is desirable for the control of pool water quality. The widespread consumption of acesulfame-K (ACE), a stable synthetic sweetener, and its complete excretion in urine, makes it an ideal urinary marker. Here we report the occurrence of ACE and its potential application in swimming pools and hot tubs. First, we developed a new method for achieving high-throughput analysis of ACE without preconcentration or large-volume injection. Analysis of more than 250 samples from 31 pools and tubs from two Canadian cities showed ACE in all samples. Concentrations ranged from 30 to 7110 ng/L, up to 570-fold greater than in the input tap water. The level of dissolved organic carbon was significantly greater in all pools and tubs than in the input water. Finally, we determined the levels of ACE over 3 weeks in two pools (110,000 and 220,000 U.S. gallons) and used the average ACE level to estimate the urine contribution as 30 and 75 litres. This study clearly shows the human impact in pools and tubs. This work is useful for future studies of the human contribution to formation of disinfection byproducts (DBPs), epidemiological assessment of exposure, and adverse health effects in recreational facilities.

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Read more at: http://pubs.acs.org/doi/pdf/10.1021/acs.estlett.7b00043

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New Zealand Association of Scientists

Submission on the Ministry for the Environment's Clean Water consultation document*

The New Zealand Association of Scientists (NZAS) is a genuinely independent association of scientists who work and lobby to:

- promote science in New Zealand,
- increase public awareness of science and expose pseudo-science,
- debate and influence government science policy,
- improve working conditions for scientists, including gender and ethnic equality,
- promote free exchange of knowledge and international co-operation, and
- encourage excellence in science.

The consultation document reflects that 'Clean Water' is an issue that New Zealanders care deeply about, placing it at the top of their list of environmental issues[1]. It is an issue than needs to be addressed, and requires substantial science input into societal decision-making processes[2].

Another report[3], released during the closing week of this consultation, shows ongoing concerns about our water resources based on the state and trends of key indicators representing both ecological health and human health during recreation.

From the broad perspective of NZAS, we note this consultation has been unusual in key respects, and we express concern that the role of science in supporting the consultation's public and stakeholder discourse has been undermined.

Our key concerns are:

1. The development of the Clean Water document is intended to reflect an ongoing consensus involving key stakeholders through the Land and Water Forum, which was established in 2009. Three key stakeholders representing widespread public interest have now withdrawn from the Forum, expressing concern that implementation is inconsistent with agreed recommendations from the Forum. This undermines the basis for the document under consultation.
2. Experts in freshwater indicators, including the President of the New Zealand Freshwater Sciences Society, have expressed public concern4 that the indicators proposed in the report are so confusing that even experts do not understand a number of issues related to the proposal. The issues have not been clarified during the consultation period.
3. There is a mismatch between the goals of indicators, desired outcomes and timeframes. For instance, the report is primarily focused on indicators of human health during recreation. In contrast, the perceptions of New Zealanders are likely to be that ecological health should be a primary goal, but is given only the weakest possible basis in section 3.4.

In light of these types of concerns, and wider submissions, we strongly urge revision of the Clean Water 2017 document and programme, and a new phase of consultation. We consider this to be an unusual request that we do not make lightly. It is important that it be considered where processes of discourse, including the Land and Water Forum and public consultation, do not appear to have operated adequately to ensure that scientific evidence is considered properly in long-term decisions. This is particularly relevant when addressing complex ecological systems with time lags or hysteresis, which cause disconnects between indicators, desired outcomes and timeframes. Under these conditions, a lack of scientific understanding informing and steering policy and management will result in a likelihood that the ecological systems will overshoot acceptable boundaries. Precaution is advised to avoid unacceptable overshooting of thresholds of ecological health – particularly where there is the threat of species extinctions. Our concerns led us to suggest that we also support the views of informed scientific and societal stakeholders requesting more targeted limit setting with a greater focus on nutrients and ecological health, as well as earlier timeframes for implementation.

Dr Troy Baisden
On behalf of NZAS Council

* Ministry for the Environment. 2016. *Next Steps for Fresh Water: Consultation document.* Wellington: Ministry for the Environment.

[1] Hughey, K.F.D., Kerr, G.N., Cullen, R. 2016. *Public Perceptions of New Zealand's Environment: 2016.* EOS Ecology, Christchurch. http://www.lincoln.ac.nz/Documents/LEaP/perceptions2016_feb17_LowRes.pdf

[2] Office of the Prime Minister's Chief Science Advisor, 12 April 2017. *New Zealand's fresh waters: Values, state, trends and human impacts.* http://www.pmcsa.org.nz/wpcontent/uploads/PMCSA-Freshwater-Report.pdf

[3] Ministry for the Environment & Stats NZ 2017. *New Zealand's Environmental Reporting Series: Our Fresh Water 2017*. http://www.mfe.govt.nz/publications/environmental-reporting/ourfresh-water-2017

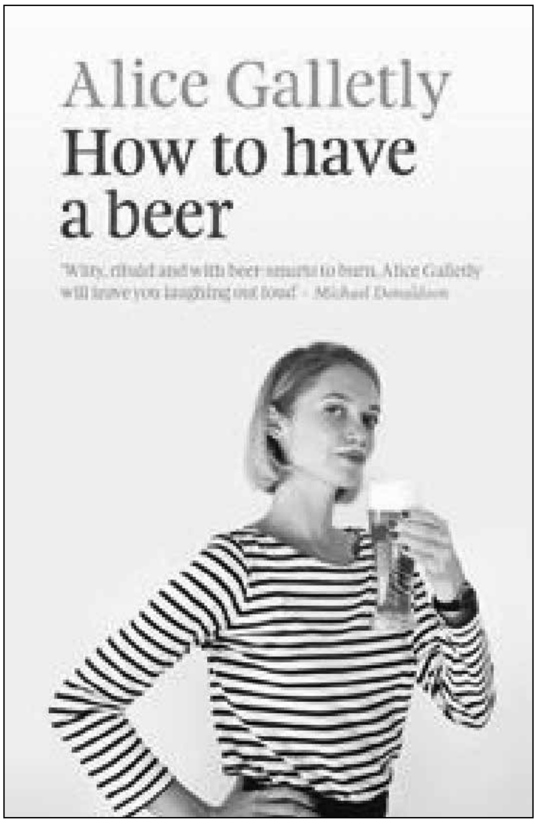
[4] Radio New Zealand 26 April 2017. Freshwater scientists confused by clean water package. *Morning Report*. http://www.radionz.co.nz/national/programmes/morningreport/audio/201841531/freshwater-scientists-confused-by-clean-water-package

Book review

Alice Galletly

How to have a beer

Reviewed by Nicola Gaston*



The Awa Press Ginger Series books, themed around the idea of introducing 'how to …' engage in various pastimes, are perhaps an unlikely venue for science communication. I started reading *How to have a beer* out of simple curiosity, sparked in part by the apparent novelty of a woman daring to flaunt her credentials as a beer expert in public, but went away musing on how interesting it is to see scientific knowledge being communicated in such a low key, but generally useful way.

The topic lends itself to a variety of glimpses of science, to be sure – from mentioning Pasteur's discovery of yeast, to discussing the various consequences bacteria can have in brewing, to dismissal of marketing claims of 'contains only 2.5 carbohydrates' as not involving valid units of measurement. There's a lot in here for scientists to like, but perhaps most of all is the validation of scientific experimentation as a way to learn: the background to the book, after all, was Galletly's experiment in tasting and blogging about 365 beers in a year, with both successes and failures accounted for along the way.

For all that I enjoyed the diversions into science along the way, however, this is not really a scientific book. But it is a form of dissemination of expertise that is deeply valuable, and successful in its goal of increasing the accessibility of a significant cultural phenomenon – the rise of craft beer – to everyone. It contains lessons on the value of continuing to learn, such as when Galletly acknowledges that "at first it felt good to make these strong sweeping statements about what I did and didn't like', a welcome note of nuance in a world in which expertise and authority are words too often used interchangeably, with no thought for the validity of personal experience.

It's also delivered with generous good humour and style, from the discussion of the modern relevance of medieval food safety laws, to the outdated assumptions behind the 'pink it and shrink it' approach of marketing beer to women. It's a fun read.

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Publisher: AWA Press, Wellington

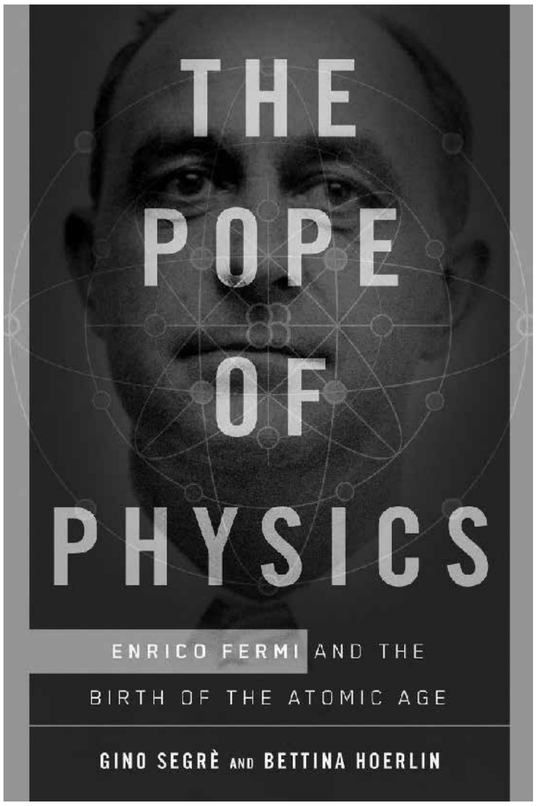
**Nicola Gaston is an Associate Professor, in the Department of Physics at the University of Auckland.*

Book review

Gino Segrè and Bettina Hoerlin

The Pope of Physics

Reviewed by Philip Yock*



Enrico Fermi was one of the towering figures of twentieth century physics and often considered the last person to have known all of physics. Not for him the title ‘theoretical physicist’, or ‘experimentalist’ – his realm was physics wherever that might take him. He made seminal contributions to quantum field theory, beta-type radioactivity, nuclear interactions induced by neutrons, nuclear fission and the origin of cosmic rays. He earned the title ‘Pope of Physics’ in his home country of Italy because his judgements on physics turned out to be, with one possible exception, unfailingly correct. He is remembered as Italy’s most famous scientist since Galileo.

This book by the husband and wife team of Gino Segrè and Bettina Hoerlin provides an engagingly written biography of Fermi’s life and achievements. It provides an excellent companion volume to the biography *Atoms in the Family* written by Fermi’s wife in 1954, which, as might be expected, provides more personal insight into Fermi’s character, and also excellent descriptions of the experiments conducted by Fermi in terms a non-scientist can readily appreciate. The present book does not provide full details of the experiments conducted by Fermi, nor the theories he propounded, but it is clear this was not the intention of the authors.

The book opens with brief remarks on Fermi’s boyhood, in which he carried out experiments on electric motors and gravity’s acceleration, and read lengthy treatises on mathematics in Latin and on physics in French. He eventually attended the Scuola Normale Superiore at Pisa and received a doctorate magna cum laude in physics. He is described as a brilliant student who was largely self-taught, perhaps as many pioneers are.

We also learn from the biography that Fermi was an inveterate scientist and teacher, who enjoyed spending time with students talking physics. He also enjoyed competitive sports such as hiking, skiing, tennis and swimming. His wife Laura studied general science at university, including physics, and she is said to have contributed to Fermi’s general happiness. He admired her wit and intelligence, which are so evident in her biography *Atoms in the Family*, and he left parenthood mainly to her.

Fermi wrote pioneering papers on the quantisation of the electromagnetic field at an early age, which placed him on a par with Paul Dirac, and these were followed by his ground-breaking theory, famously rejected by *Nature*, of beta-type radioactivity, in which he correctly proposed that particles actually change their identities in the decay process.

In the early years, while Fermi was still in Rome, an accomplished group formed around him known as ‘the boys’. This included Emilio Segrè, Franco Rasetti, Edoardo Amaldi, Oscar D’Agostino, and Bruno Pontecorvo. Under Femi’s leadership they conducted experiments in which elements covering most of the periodic table were bombarded with neutrons. These led to the discovery of many new nuclear isotopes and comprised Fermi’s Nobel Prize-winning work.

**Philip Yock is a physicist who was formerly at the University of Auckland*

Published 2016
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Publisher, Henry Holt and Company, New York

These experiments also led to the discovery that slow neutrons were more effective in inducing nuclear interactions than fast neutrons, a discovery which reputedly used a goldfish pond at Rome University as a moderator to slow neutrons down.

But the neutron experiments included one possible blunder, viz. the apparent production of element 93 when uranium (element 92) was bombarded with neutrons. In fact, nuclear fission occurred in this process, leading to the emission of fragments half-way down the periodic table, but this surprising interpretation was not immediately evident. It was this surprising result of 'nuclear fission' that heralded in the atomic age, as the fission fragments carried away enormous amounts of energy.

Fermi's experiments with neutrons followed on from Rutherford's experiments in which elements were bombarded with alpha particles. However, in Rutherford's experiments, electrostatic repulsion between the positive alpha particle and the atomic nucleus tended to keep them apart, whereas in Fermi's experiments the neutron, being neutral, could freely enter the target nucleus.

In 1939, Fermi and his family left Italy for the USA after the award of the Nobel Prize. Fermi had visited the United States before and enjoyed the atmosphere there for physics. Fermi is described as being grateful to be leaving Italy because of the rise of Fascism and his wife Laura being Jewish. The offer of a position at Columbia University in New York was welcome.

At that time, the physics world was abuzz with the process of nuclear fission and the possibility of using it to build bombs of unprecedented power. Fears were high that physicists in Germany might be working toward this end. This led to efforts in the USA and the UK to consider the feasibility of building such bombs, and Fermi was recruited to lead the construction of the world's first nuclear reactor at Chicago University as part of the effort.

This is well described in the biography. It is said that Fermi was driven largely by his admiration of physics, whereas other physicists were more attuned to the war effort. In any case, with the entry of Japan into the conflict, these efforts were redoubled with a result the world knows only too well.

After the war, the Fermis moved to Chicago, but at the early age of 53, Enrico Fermi passed away after a short battle with cancer. As noted by Segrè and Hoerlin, he passed on a legacy for doing calculations in physics in one of two ways: one, and Fermi's preference, was to have a clear physical picture of the process being calculated; the other was to have a precise and self-consistent mathematical formalism.

Fermi died ten years before the quark model was proposed in 1964. It would have been very interesting to hear his viewpoint on this model – was it a clear physical picture, a self-consistent mathematical formalism, or something else? Sadly, we shall never know.

This reviewer confidently believes *The Pope of Physics* by Segrè and Hoerlin will make interesting and instructive reading for any student or historian of modern physics.

ASSOCIATION FOR WOMEN IN THE SCIENCES • 2017

Celebrating female scientists – AWIS2017

Emma Timewell
National Convenor, AWIS

This July, New Zealand's female scientists from the past, present and future will be celebrated as Auckland hosts the ninth triennial Association for Women in the Sciences conference.

AWIS was created more than 30 years ago, and the conference offers a great opportunity to reflect on how the science sector has changed over this time and how the organisation can best support its members into the future. There will be sessions that consider the changing needs of women, particularly those in science, alongside the conference's customary streams focused on professional development and active research.

The two-day conference will offer opportunities for women working, or wanting to work, in any field of science to develop their skills to benefit both their careers and personal lives. Key to the event is the range of networking opportunities allowing attendees to learn from each other's stories. The programme has been developed to appeal to all women with an interest in science, including research scientists, administrators, businesswomen and educators. The programme is also intended to be accessible and of interest to young women nearing the end of their secondary or tertiary studies.

AWIS 2017 will start with a summary of current research by Jane Parker and Nazim Taskin of Massey University looking at New Zealand women's career progress and aspirations, which will help to inform our discussions over the two days. This theme will continue on the first day with a session that looks at where AWIS started, how things have changed since its inception, and the key drivers for women entering science now and in the future; and on the second day with a panel discussing what the issues are for women in science, including representatives from the Ministry for Women, UNESCO and the Royal Society of New Zealand.

Throughout the conference programme there will be three concurrent streams, themed around Science Snapshots, Development, and Affecting Change. The Science Snapshots will showcase how new technologies and techniques are being applied to science looking at the past to the future, with sessions based around archaeology, psychology and behaviour, computer science, and futuristic science (or 'rockets, robots and awesomeness' as we have termed it!). The Development stream will look at a range of professional and personal development themes – from work–life balance, to writing research proposals, communication skills and mentoring. Affecting Change will focus on ways in which we can change people's attitudes to science, through museums, citizen science, and the media, as well as showcasing projects that have changed societal attitudes to wider issues such as health and safety and gender equality.

The planning committee have made sure there's also plenty of time to relax and celebrate, including the formal presentation of the Miriam Dell Award* to Ros Kemp of the University of Otago, and, of course, a fantastic conference dinner.

Thanks to funding from the New Zealand National Commission for UNESCO, attendees at AWIS2017 have the opportunity to mentor a female student from a South Auckland school. The Shadow a Scientist programme will offer 12 late-stage secondary students the opportunity to attend the conference and be assigned a mentor for the two days. During breaks, the students will be expected to get to know their mentor and meet other attendees, making the most of the opportunity to broaden their knowledge of science careers that might be available to them. After the conference, the students will be asked to create a written or multimedia summary of what they learnt and a profile of their mentor that can be shared via AWIS' website and social media to help other budding scientists make decisions about how they can enter a career in science.

AWIS would like to thank the sponsors of the conference – Te Pūnaha Matatini, The Ministry of Business, Innovation and Employment, Plant & Food Research, The MacDiarmid Institute, The University of Auckland Faculty of Science, the Dodd-Walls Centre and the Cawthron Institute.

**This year's Miriam Dell Award nominations will open in May for those interested in giving recognition to those who mentor females in science.*

The conference is on 13–14 July at the Heritage Hotel in Auckland and there is a special accommodation rate on the conference website

Registration for AWIS2017 is now open

Go to: http://www.scienceevents.co.nz/awis2017

Also keep an eye out for speaker and activity announcements on Facebook and Twitter, @awisnz #awis2017

Vale

Dora Suuring, ***Dutch Resistance fighter, chemist, lecturer, teacher, NZAS Council Member: b. 10 July 1914, Amsterdam; m. (1) Sal Breemer, 1939 (diss), (2) Henk Suuring (dec.) 1946; d. 31 March 2017, Waikanae, aged 102.***

Dora Suuring once said she was only a small cog in the big machine that was the Dutch Resistance during World War II. But her work as a skilled forger helped save the lives of scores of fellow Jews. She lived under a false name in occupied Holland where she helped to get Jewish families into hiding and arranged for children to be taken care of under false identities, using her chemical knowledge to forge identity papers, food coupons and passports.

Born Dora Polenaar in Amsterdam's Verhulststraat, she was raised with her three sisters. She chose to study science rather than become a lawyer like her father, and graduated PhD in organic chemistry from the University of Amsterdam. Before war broke out, she was a teacher at a Montessori school in Amsterdam. Her first husband, Sal, taught at a Jewish secondary school nearby.

As the Germans swept into Holland in May 1940, Dora's parents and sisters went into hiding and she and her husband tried to leave for England, but their vessel never left. Later, she and Sal were persuaded to go to a special 'safe' camp for Jews in rural Holland. 'The Germans offered teachers, lawyers, those in the arts, to go to this camp to be saved. I didn't want to go because I didn't trust them, but my husband was very scared so we went', she revealed in a documentary, *Lest We Forget*. However, it soon became clear that the camp was a way-station for the deportation of thousands destined for slavery or death in Nazi concentration camps. So, when the Germans started transporting inmates, Dora and her husband escaped through a hole in the camp fence.

She began her resistance work in Deventer, in the east of Holland. Her husband had left her after their escape from the camp, and she later moved back to Amsterdam, where she continued her resistance work.

Blonde and blue-eyed, she was not readily identifiable as Jewish and was able to move about relatively freely with her false identity, although she was nearly discovered on several occasions. One of these was when German officers were carrying out an identity check on a train she was on. Realising she did not have her papers, she hid undetected in the lavatory. Altogether she lived under four different names.

Using her skills as a chemist, she took a job in a baking powder factory, which gave her access to the chemicals used to remove photos, fingerprints and stamps from ID cards so that new papers could be forged for herself and others associated with the Dutch underground. She and her fellow Resistance workers also made false coupons and bribed farmers for food in exchange for household items and clothing and later, gold and diamonds.

As the war drew to a close, she was commandeered as an interrogator to whittle out those who had collaborated with the Germans.

Around this time she met her second husband, Henk Suuring. The couple began their new life in New Zealand in 1948.

Though she held a doctorate, Dora had great difficulty in getting this recognised by the then Education Department, so she started teaching in private schools, firstly chemistry at Chilton Saint James in Lower Hutt and later at Queen Margaret College in Wellington. When she subsequently got a position at Onslow College the headmaster was disturbed to find her abilities unrecognised and demanded that the Education Department accept her qualifications. Dora eventually moved on to Tawa College, then to Wellington Teachers College, and lastly to Wellington Polytechnic.

Dora joined the Council of New Zealand Association of Scientists in 1979, at the invitation of her fellow Jew, John Offenberger, who was Vice-President of the Association at the time. She served on Council for 11 years, acting as Secretary for three of them. She was teaching science at Wellington Teachers' College and became involved with the Association's lobbying to improve the participation of women in science. She expressed particular interest in research in teaching and in social responsibility of scientists (particularly teachers) and helped the Association's initiative to promote tertiary courses in Science and Technology in Society.

Dora is survived by two sisters, two daughters, two grandchildren and four great-grandchildren. She touched the lives of many here in New Zealand over her long lifetime.

Sources: Anja Snowsill, The Dominion Post (Hank Schouten), The Press (Rodney Laredo), Chemistry in New Zealand Journal, Lest We Forget (AC Productions), Boyd Klap, RNZ, Geoff Gregory (formerly NZAS Council)

The New Zealand Association of Scientists (Inc.)
PO Box 1874
Wellington 6140
New Zealand

21 November 2016

Media release

Director of GeoNet needs to be heard

The New Zealand Association of Scientists (NZAS) is alarmed at reports[1] that the Acting Civil Defence Minister, Gerry Brownlee, is 'furious with GeoNet comments' made by the service's Director, Dr Ken Gledhill[2].

'GeoNet is an important service in which all New Zealanders have an interest', said NZAS President Craig Stevens, 'and if Dr Gledhill can suggest cost-effective measures to make New Zealand safer, he should be encouraged to say so, and publicly.'

There have been other media reports[3] that have questioned the quality of the response, and these concerns should rightly be taken on board by all involved, including the scientific community. It is of deep concern that the Government response is to vilify voices that seek to encourage us to learn from a post-mortem of events.

The magnitude 7.8 Kaikoura earthquake was unique amongst the many events GeoNet has responded to in recent years, because it produced a significant tsunami immediately along the New Zealand coastline. This tsunami potentially threatened population centres, especially the Wellington region, within a short time.

The Association calls on the Government to be responsible in its discussions with the science agencies, such as GNS Science, that support critical government services, such as the Ministry of Civil Defence and Emergency Management.

To maximise the safety of New Zealanders, the Association recommends that the Government avoid actions that might lead to the repression of scientific advice to the public.

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[1] http://www.nzherald.co.nz/nz/news/article.cfm?c_id=1&objectid=11751707

[2] http://info.geonet.org.nz/pages/viewpage.action?pageId=20545630

[3] http://www.nzherald.co.nz/toby-manhire/news/article.cfm?a_id=810&objectid=11750125

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The New Zealand Association of Scientists (Inc.)
PO Box 1874
Wellington 6140
New Zealand

2 February 2017

Media release

Science is, sometimes, political

The New Zealand Association of Scientists (NZAS) is deeply concerned by the impact of the new US administration.

'We've just gone two weeks with the new US administration and we are witnessing a geopolitical shakeup that is without precedent', said NZAS President Craig Stevens. 'The rise of social media has reduced the time for a community to respond to an event down to mere minutes. At the same time, communities are both many - and global. The radical changes being made by the Trump administration ripple across the globe in the blink of a smart-phone.'

As an independent body seeking to promote science, the NZAS has six main aims (www.scientists.org.nz) – each one is and will be impacted by the radical changes being wrought by one of the planet's dominant nations. This dominance feeds through into economic influence, migration, regional stability and science.

We seek to promote science in New Zealand. Science is now global, scientists come from all-over and go all-over. We collaborate, we consolidate, we share knowledge, we discover – globally.

The world would not be sure that the climate is changing rapidly due to greenhouse gas emissions without the efforts of scientists of all nationalities. Science and the scientific community cannot tolerate discrimination against people on the basis of their place of birth or religion. In fact, the Trump Administration's travel ban has horrified the global scientific community. This ban is completely immoral in the context of the current international refugee crisis. It will also retard scientific progress in the United States and the rest of the world at just the time when our civilisation needs science the most.

We seek to increase public awareness of science and expose pseudo-science. The US Administration is using new, and seriously partisan, media to deconstruct science. It's happened before with abhorrent consequences.

We debate and influence government science policy. With science being central to so many aspects of our lives, in particular those that we all have in common such as climate and health, these debates cross borders.

We seek to improve working conditions for scientists, including gender and ethnic equality. This is completely central to societal advances of the last decade, largely facilitated by global communications and social media, enabling battles to be fought and won with contributions from all over the planet. And these fighters seek open knowledge, transparency, justice, and quality of life for all.

We promote free exchange of knowledge and international co-operation. A couple of weeks ago this seemed a given. Today, that this is so much less certain is remarkable in itself.

And finally we encourage excellence in science. Excellence comes in many forms – academic excellence is just one, and usually insufficient on its own to be good for much. We put forward the idea that in this age, everyone is a scientist – or part of the science ecosystem. This doesn't mean everyone has to read up on Rutherford and Salk, but rather they everyone should be able to value – and be able to participate in – the search for truth and understanding.

Stevens comments: 'There are so many, many challenges facing our species. Population, climate, equality, health, environment and more besides. It's one thing to make science struggle to support and justify its activities – that is only appropriate. It is quite another to actively hunt it down and tear down truths.'

Late last year the NZAS chose to target the theme of science in society, for 2017. What we didn't realize was that this was going to become street-warfare. In the coming months there will be global demonstrations (in NZ see @ScienceMarch_NZ on twitter). This is not just scientists protesting about science funding – it is about the serious consequences for all of us if science – and other forms of scholarship – are ignored and undermined. 2017 is also an election year and a time when we need to support the values we want for the future. The comfort some of us are lucky enough to experience in NZ naturally enough drives complacency. But the time for complacency has passed.

If you think science is apolitical, then ask yourself whether you also believe science can work under all political regimes[1].

Contact: NZAS President Associate Professor Craig Stevens, email:
president@scientists.org.nz, ph: 027 419 1855

[1] https://twitter.com/hendysh/status/826235065256415232

News

The Productivity Commission released its final report 'New models of tertiary education' 21 March 2017

In 2015 the Government asked the Productivity Commission to investigate how trends in technology, internationalisation, population, tuition costs and demand for skills may drive changes in models of tertiary education.

The inquiry followed on from the 2014 *Innovations in Tertiary Education Delivery Summit*, which considered emerging models of tertiary education provision and discussed challenges to shifting away from traditional models.

The report released in March 2017 inquired into how well New Zealand's tertiary education system is set up to respond to emerging trends in technology and the internationalisation of education, and changes in the structure of the population, and the skills needed in the economy and society. As part of the inquiry, the Commission was asked to identify potential barriers to innovation.

'A good tertiary education system is one that meets the needs of all learners – including those from diverse backgrounds and with diverse goals. Our current system serves many students well. But it could be better, and it could do more to extend the benefits of tertiary education to groups who currently can't access it' says Commission Chair, Murray Sherwin.

It is a tightly controlled and inflexible system commented Mr Sherwin. 'Providers have too few incentives to find better ways of reaching and teaching learners This report and its package of recommendations seek to give providers the scope to innovate in the delivery of tertiary education, and incentives to do so.'

Key recommendations include:

- better quality control and self-accreditation for strong performers;
- making it easier for students to transfer between courses;
- abolishing University Entrance;
- better careers education for young people;
- enabling tertiary institutions to own and control their assets;
- making it easier for new providers to enter the system; and
- facilitating more and faster innovation by tertiary education providers.

The full report, an overview of the report and submissions received during the inquiry can be down loaded at:

http://www.productivity.govt.nz/inquiry-content/2683?stage=4

News

Pollen from New Zealand may be altering remote deep-sea ecosystems

NIWA scientists have analysed sediment samples from the Kermadec and Tonga trenches north of New Zealand. The findings show pine pollen is common, even in these remote deep-sea ecosystems. Pollen was found to be particularly abundant in the deepest part of the Tonga Trench, some 10,800m down – and the second deepest point of the world's oceans.

NIWA marine biologist Dr Daniel Leduc says the steep topography of trenches is thought to funnel fine particles that sink from the surface waters of the sea, leading to high accumulation of fine material, including pollen, at their deepest point.

The study also found that areas where pollen is most abundant harbour the most life, suggesting that pollen may be a food source for some deep-sea organisms. Pine pollen was observed inside small, single-celled organisms called gromiids, which ingest the pollen and may derive nutritional benefits from it, Dr Leduc says. 'This unsuspected source of land-derived food originating from exotic pine plantations may be altering deep-sea food webs. Deep-sea ecosystems are typically characterised by very low availability of food sinking from the surface, and any new food source is likely to get used by the organisms that live in the sediments.'

Pines produce particularly large amounts of pollen which can travel very long distance by wind and ocean currents, reaching remote offshore areas where little or no other pollen is found. Dr Leduc says the replacement of native forest by forests of exotic pine probably led to an increased transport of pollen to offshore areas. Monterey pine was introduced to New Zealand in the early 20th century, with more than one million hectares of pine forest now established. These forests produce an estimated 4.5 million tons of pollen each year.

Dr Ashley Rowden a NIWA scientist who co-authored the study said 'The accumulation of pine pollen may represent an unsuspected carbon sink. The gradual burial of pine pollen, part of which is highly resistant to decomposition, likely contributes to the sequestration of land-derived carbon.'

Further research is planned to investigate just how much carbon and nutrients are being transported by pine pollen to the deep sea around New Zealand, and to better understand the contribution of pollen to the diet of deep-sea organisms.

Published on-line 19 April 2017, see: http://rdcu.be/rtjd scientists.org.nz

THE NEW ZEALAND ASSOCIATION OF SCIENTISTS

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NZAS Annual Conference
21 June 2017
Royal Society, Wellington

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NZAS
New Zealand Association of Scientists

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Please complete this form and return it with payment to:

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Name..Preferred title...

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NZAS is an independent organisation working to:

- Promote science for the good of all New Zealanders
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- Promote free exchange of knowledge
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