GNS SCIENCE
TE PŪ AO

GNS SCIENCE
2023 ANNUAL REPORT
PART 1 – HIGHLIGHTS

SCIENCE THAT MATTERS

WHERE IT MATTERS MOST

MAP KEY

- NATURAL HAZARDS AND RISKS
- ENERGY FUTURES
- ENVIRONMENT AND CLIMATE
- LAND AND MARINE GEOSCIENCE

FLYING HIGH TO MAP BELOW GROUND

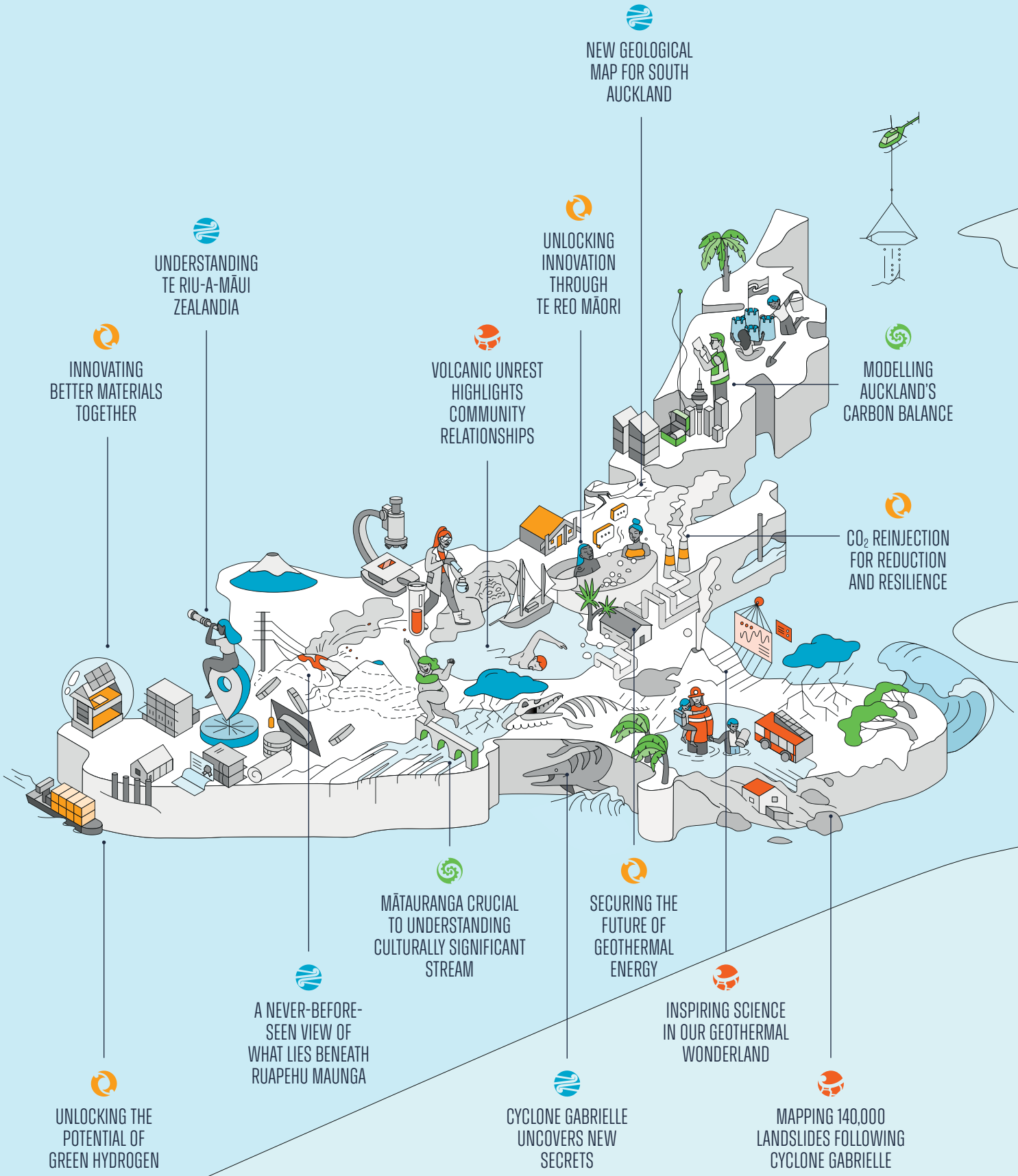
SEDIMENT SECRETS INFORM CONSERVATION EFFORTS

MONITORING THE MOTU

UNLOCKING ANTARCTICA'S HISTORY

CITIZEN SCIENCE MAPPING METALS IN SOIL

PREPARING AOTEAROA FOR EARTHQUAKES


NEW GEOLOGICAL MAP FOR SOUTH AUCKLAND
UNDERSTANDING TE RIU-A-MĀUI ZEALANDIA
UNLOCKING INNOVATION THROUGH TE REO MĀORI
INNOVATING BETTER MATERIALS TOGETHER
VOLCANIC UNREST HIGHLIGHTS COMMUNITY RELATIONSHIPS
MODELLING AUCKLAND'S CARBON BALANCE
CO_2 REINJECTION FOR REDUCTION AND RESILIENCE
MĀTAURANGA CRUCIAL TO UNDERSTANDING CULTURALLY SIGNIFICANT STREAM
SECURING THE FUTURE OF GEOTHERMAL ENERGY
A NEVER-BEFORE-SEEN VIEW OF WHAT LIES BENEATH RUAPEHU MAUNGA
INSPIRING SCIENCE IN OUR GEOTHERMAL WONDERLAND
UNLOCKING THE POTENTIAL OF GREEN HYDROGEN
CYCLONE GABRIELLE UNCOVERS NEW SECRETS
MAPPING 140,000 LANDSLIDES FOLLOWING CYCLONE GABRIELLE

NATURAL HAZARDS AND RISKS

Growing our understanding of natural hazards, building resilience to natural hazard events and improving our ability to manage risk associated with different natural hazards.

ENERGY FUTURES

Helping transition our national energy ecosystem to a low-carbon, resilient, cost-effective alternative through improved energy generation approaches, storage methods and utilisation models.

ENVIRONMENT AND CLIMATE

Understanding the drivers of climate and environmental changes and their impact on ice sheets, groundwater, and ecosystems to mitigate warming and adapt to unavoidable sea level rise.

LAND AND MARINE GEOSCIENCE

Building the fundamental understanding and revealing the processes that continue to shape Te Riu-a-Māui Zealandia and impact our wider society and economy.

Presented to the House of Representatives pursuant to the Crown Research Institutes Act 1992.

Our Annual Report is presented in two parts – Highlights (Part 1) and Performance and Financials (Part 2). Together, these documents fulfil our annual reporting responsibilities under the Crown Research Institutes Act 1992 for the year ended 30 June 2023.

The Performance and Financials (Part 2) includes performance information, the report of the directors, financial statements, and independent auditor's report.

Our Annual Report is also available in digital format at www.gns.cri.nz

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www.gns.cri.nz

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INTRODUCTION FROM THE CHAIR AND CHIEF EXECUTIVE


Mount Tarawera

KIA ORA AND WELCOME TO GNS SCIENCE'S ANNUAL REPORT, WHERE WE CELEBRATE SOME OF THE MANY HIGHLIGHTS ACHIEVED BY OUR TEAMS THROUGHOUT THE YEAR.

Science that matters, where it matters most – our theme this year champions the material impact of our mahi. Throughout Aotearoa New Zealand, and indeed across the world, the work GNS Science undertakes directly impacts communities, with tangata whenua at the heart of all that we do.

Countries around the world are continuing to address the lingering impacts of the COVID-19 pandemic while collectively recognising that we are facing challenges on an unprecedented scale because of the changing global climate. Cyclone Gabrielle and other recent extreme weather events have had a profound impact across Aotearoa New Zealand. These types of events are likely to become more intense and more frequent, emphasising the importance of increased resilience and demanding bold and innovative action.

GNS Science has played a crucial role in the response to these events, supporting agencies and stakeholders on the ground and informing and aiding the recovery of affected regions. We have also been developing and delivering new knowledge and tools to support our national Rangatira, and the communities that depend on their decisions in our rapidly changing world. Evidence-informed policy and decision-making, along with the role of science in generating new knowledge to help mitigate these threats, is critical to protecting lives, livelihoods, and the future of our planet.

OUR SCIENCE, INNOVATIVE SOLUTIONS AND KNOWLEDGE MATTERS AND IS CONTRIBUTING TO AOTEAROA NEW ZEALAND BECOMING CLEANER, SAFER, AND MORE PROSPEROUS.

Left: ***David Smol,*** *Chair*

Right: ***Chelydra Percy,*** *Chief Executive*

OUR SCIENCE

GNS undertakes research, develops tools, and shares knowledge that increases the country's resilience to natural hazards and enhances our ability to understand geological and Earth-system processes. Our focus is addressing the science needed to future-proof Aotearoa New Zealand in a changing climate. We are driving innovation and sustainable economic growth in the energy sector and developing new materials, products and approaches to assist other agencies to better manage risk, environment, natural Earth, and groundwater processes. We are working with our customers, partners, Māori and with communities to identify new and rapid solutions that will safeguard and benefit people and the planet.

Our Annual Report shares some of the highlights of the work we have undertaken this year. Highlights such as the launch of the revised National Seismic Hazard Model. The internationally endorsed model incorporates new scientific insights from the last decade and represents a monumental collaborative effort from many researchers and agencies. This new view of Aotearoa New Zealand's earthquake hazard is a foundational platform from which we can collectively improve the resilience of our national buildings and infrastructure, and urban environments.

We are very proud of RiskScape™, winner of the Best Hi-Tech Solution for the Public Good in the NZ Hi-Tech Awards. RiskScape™ is a software tool that enables users to assess risk to buildings, infrastructure and people from natural hazards such as volcanic eruptions, earthquakes, landslides, tsunami and floods. The award celebrates years of hard work by GNS Science and our partners at NIWA, Toka Tū Ake EQC and Catalyst.

Lakes380, a five-year Endeavour programme co-led by GNS Science and the Cawthron Institute, was completed during the year. This programme combined assessments of contemporary lake health with assessments of past environmental conditions (using evidence preserved in lake sediments) on a national scale. The outcomes are diverse and far-reaching. They include the development of tools and data for enhanced lake management, engaging digital stories that reconnect our people with our lakes, and a range of educational resources. The programme is facilitating much improved environmental outcomes, benefitting individual species and entire ecosystems.

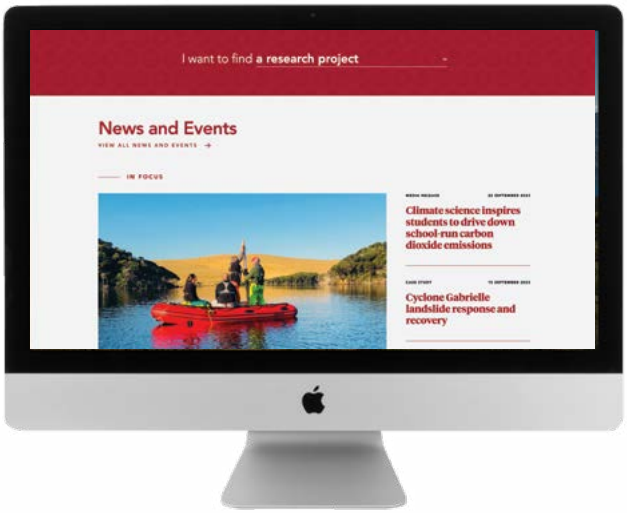
GNS Science's first spin-out company, Bspkl, was launched in April and is an exciting step towards unlocking a net-zero carbon future, meaningfully powered by green hydrogen. It is a new stand-alone commercial entity out of GNS Science, brought to life by funding from investors including WNT Ventures and the WNT group, Investible. Bspkl technology is helping to accelerate hydrogen's widespread adoption as a clean energy source through its innovative approach to manufacturing catalyst-coated membrane for hydrogen electrolysers.

5

LAKES380 IS A FIVE-YEAR ENDEAVOUR PROGRAMME CO-LED BY GNS SCIENCE AND THE CAWTHRON INSTITUTE

8

BSPKL IS AN EXCITING STEP TOWARDS UNLOCKING A NET-ZERO CARBON FUTURE



INVESTMENT

This year we have continued to invest in GNS Science's infrastructure, systems and processes. We introduced, and began to embed Workday, a system that has replaced our Financial, Human Resources and Project Management systems. We also completed Phase Two of the project – the provision of an adaptive planning tool, learning management system and talent optimisation system. This work was done in partnership with the Institute of Environmental Science and Research (ESR), reducing implementation costs and ongoing licensing fees for both organisations.

It is critical that we have fit for purpose facilities to support the delivery of great science and bring people together to enable connection, collaboration, and innovation. We are actively working with the Ministry of Business, Innovation and Employment (MBIE) and other Wellington-based research organisations on the Wellington Science City initiative. Through the creation of three multi-institution research hubs, Wellington Science City aims to make Wellington a vibrant, resilient, and adaptable centre of research, science and innovation by 2030.

The redevelopment of our Wairakei site has also remained a priority, with the demolition of an unsafe and unused building and design planning for a new Volcanology and Visitor Centre.

Our new website, launched this year, makes it easier for stakeholders, the public and staff to find the content they are looking for, while enjoying a completely new and much improved user experience. The platform brings our people front and centre, connecting our research and stories to the people behind them. Our science can now be shared in a bold, new, digitally friendly format across desktop, tablet and smartphone.

ENGAGEMENT

We are firmly committed to supporting key Government priorities and initiatives associated with the research, science and innovation system, including the Te Ara Paerangi – Future Pathways programme. Te Ara Paerangi provides an exciting opportunity to reimagine the system and we are actively engaging in this work.

Our support for Māori participation in science has progressed under the guidance of Te Punawai o Rangiātea, our Māori Strategy. We are thrilled with the impact of our Ahunuku Māori Summer Scholarship programme, a partnership with Te Herenga Waka Victoria University, and our internship programme. Within GNS Science, our Te Reo, Tikanga and Te Tiriti o Waitangi training programmes remain well supported.

We acknowledge the Whakaari/White Island tragedy – the survivors, those that lost their lives, their whanau, Ngati Awa and the community, our staff, and all those affected by the eruption. We continue to cooperate with the legal proceedings, and with the coronial enquiry, and our thoughts remain with all involved.

As we reflect on the year that was, there is a sense of achievement and emerging optimism. We have navigated the lasting effects of the global pandemic, a series of significant hazard and climate related events and escalating costs that have tested the nation's resilience. We have delivered science that matters and has made a positive contribution to society, industry, communities and tangata whenua.

Lake Taupō

But there is more to do. A key focus for GNS in the coming years is to improve our financial resilience and continue to improve our overall organisational performance as we navigate the many challenges and opportunities ahead.

In closing, we would like to thank Dr Nicki Crauford, who retired as Board Chair in May 2023, for her dedication and invaluable service to GNS Science over the past eight years.

We would also like to thank Ian Simpson, who resigned this year after five years as Chief Executive, for his valuable contribution to GNS Science.

This year, we welcomed three new Board members, David Smol (Chair), Olivia Esterhazy and Brian Young. They bring extensive corporate and governance experience to GNS Science, and we look forward to their positive contribution.

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THIS YEAR, WE WELCOMED THREE NEW BOARD MEMBERS

Finally, we would like to thank the GNS Science Board and the Executive Team for their support this year, and acknowledge the tireless work of our staff, whose contributions to GNS Science's success have been extraordinary.

David Smol
Chair

Chelydra Percy
Chief Executive

TE WAIPOUNAMU

GEOLOGICAL OPPORTUNITIES AND RISKS ABOUND IN EQUAL MEASURE IN THE STUNNING GEOLOGICAL LANDSCAPES OF THE SOUTH ISLAND.

THE ISLAND'S MOST PROMINENT NATURAL FEATURES HAVE BEEN FORMED AND CHANGED OVER TIME BY TECTONIC FORCES, AND ITS LOCATION ALONG THE BOUNDARY OF THE PACIFIC AND AUSTRALIAN PLATES MAKES IT A HOTSPOT FOR TECTONIC ACTIVITY AND THEREFORE, RESEARCH.

TE WAIPOUNAMU ALSO OFFERS VALUABLE SCIENTIFIC INSIGHT INTO THE PROCESSES AND IMPACTS OF CLIMATE CHANGE THROUGH THE STUDY OF GLACIERS, GROUNDWATER IN LOW-LYING COMMUNITIES, AND OF COURSE, SEA LEVEL RISE AND CHANGES TO ICE SHEETS IN NEIGHBOURING ANTARCTICA.

LAND AND MARINE GEOSCIENCE

UNLOCKING ANTARCTICA'S HISTORY

GEOMAP ANTARCTICA, THE WORLD'S FIRST OPEN-ACCESS GEOLOGICAL MAPPING DATABASE OF THE WHOLE FROZEN CONTINENT, REPRESENTS A GROUND-BREAKING MILESTONE IN GLOBAL ANTARCTIC RESEARCH.

The newly developed GeoMAP captures over 52,000 km^2 of the exposed rock and sediment that make up the mountains and surfaces of Antarctica. The comprehensive database brings together all historical and existing geological data of the continent.

Understanding Antarctica's geosphere is critical if we are to understand the continent's major role in global climate, and thus, what it might have in store for our climate future. GeoMAP will allow scientists across a variety of disciplines to examine how rock substrate influences biology and ecology, local climate and melting, and the behaviour of ice.

"By capturing and refining all the existing geological map data of Antarctica, we have purposefully created GeoMAP to be a fundamental, continent-wide, and open-access digital resource" says GNS Science Principal Scientist and GeoMAP project leader, Simon Cox.

"We believe GeoMAP will be used in, and evolve with, a wide breadth of future research across the world."

Developing the GeoMAP was a large-scale and several-year effort, led by GNS Science out of the Scientific Committee on Antarctic Research (SCAR). It brought together an international team, involving principal collaborators from at least 14 nations.

To construct GeoMAP, the team captured all existing geological information from early twentieth century hand-drawn maps, and digitised hard-copy regional maps, and integrated this with modern high-resolution imagery and datasets.

"IN MANY WAYS GEOMAP IS LIKE A WIKIPEDIA OF ANTARCTIC GEOLOGY. IT IS A COLLECTION OF GEOLOGICAL INFORMATION, GATHERED FROM EXISTING MAPPING OF THE GEOLOGY OF THE REGION, ALL COMPILED INTO A MODERN FRAMEWORK," SAYS SIMON.

Upon its release, GeoMAP was widely recognised and celebrated by researchers and stakeholders across the globe. GNS Science led a promotion campaign across media and social channels that created significant excitement about the release and drove high engagement with end-users.

"We're pleased to see the high degree of international cooperation that has helped deliver this new map of Antarctica and the high level of interest from the geoscience and biological science research communities," says Gary Wilson, GNS Science's General Manager Research Strategy and Partnerships.

DISCOVER MORE:
gns.cri.nz/news/new-map-unlocks-deep-digital-data-of-antarcticas-history

doi.org/10.1038/s41597-023-02152-9

ENVIRONMENT AND CLIMATE

FLYING HIGH TO MAP BELOW GROUND

WAS IT A BIRD, WAS IT A PLANE... OR WAS IT A GIANT ELECTROMAGNETIC SCANNER HANGING FROM A HELICOPTER?

Last summer, GNS Science undertook a 'summer of SkyTEM' surveys in Northland, Wairarapa, and Southland.

These surveys reveal where groundwater is stored, how it flows, and how it interacts with surface water. The insights collected are an important step for Aotearoa New Zealand's freshwater resilience and can make a vital contribution towards management decisions that support Te Mana o Te Wai.

GNS Science Hydro-Geophysicist, Zara Rawlinson, says that communities and councils are often faced with a scarcity of information when it comes to important decisions around land and water management.

"Using state-of-the-art SkyTEM technology means we can create large and robust data sources to assist with long-term water management solutions that are environmentally, economically and socially sustainable."

Most existing information about aquifers is only available where boreholes have been drilled. This typically limits the data to relatively shallow depths and provides poor spatial coverage.

SkyTEM's aerial mapping covers large areas of ground quickly and cost-effectively, providing detailed data to around 500m below ground. This geophysical dataset, combined with other information such as data from groundwater bores, helps to create 3D aquifer maps and models that can inform groundwater management decisions.

"SkyTEM allows us to characterise our groundwater systems so that they can be well managed. This will ensure that we don't overuse or damage a resource that's only going to become more critical as the climate changes," says Richard Levy, GNS Science Environment and Climate Theme Leader.

The recent surveys were part of GNS Science's expanded SkyTEM Airborne Electromagnetic (AEM) surveying programme, and build on the first survey done in Hawke's Bay in 2020. Hawke's Bay SkyTEM data has been made accessible through the 3D Aquifer Mapping project – a world-first online map that allows users to create virtual drillholes and 2D slices to explore the aquifer beneath their feet. Our experts are currently working with Hawke's Bay Regional Council on the final hydrogeological models.

The SkyTEM Hawke's Bay and Wairarapa surveys were partially funded by Kānoa (Provincial Growth Fund) for the Hawke's Bay and Greater Wellington Regional Councils. The Northland and Southland surveys were carried out under Aqua Intel Aotearoa, a partnership between GNS Science and Kānoa.

DISCOVER MORE:
storymaps.arcgis.com/stories/ea328f3a17f64daeae58d516d4433511

aquaintel.co.nz

TROUGH LAKE, ANTARCTICA

CONNECTING THE DOTS


Lower Hutt Events Centre

COLLABORATION IN SCIENCE IS ESSENTIAL TO FOSTER THE EXCHANGE OF DIVERSE IDEAS, EXPERTISE AND RESOURCES, AND ACCELERATE THE PACE OF DISCOVERY AND INNOVATION.

The better connected we are, the better we can collaborate on complex, interdisciplinary research questions that require a collective effort to address.

Our 2023 Staff Conference proved a welcome opportunity to build those essential connections. The two-day event marked the first time staff from across our five worksites had gathered in person since the previous conference in 2019. Over 450 staff attended the event in Lower Hutt, Wellington.

Themed 'Connecting the Dots', the conference programme was designed to help our people connect with each other, with the business and their place in it. Social opportunities, workshops, and team-building sessions allowed time for colleagues to reconnect or to meet in-person for the first time.

The event was an opportunity for the GNS Science whānau to talk and learn about the incredible and diverse work we do. Each of our science themes hosted a lightning talk session, where they shared 'bite-sized' updates and insights from their projects and programmes.

GNS Science Land and Marine Theme Leader, Phaedra Upton, says it was important to her that the conference talks reflected the connected way in which work is delivered across the organisation.

"I wanted to showcase the many pairs of hands that make it possible for us to deliver our work. It was important to me that it wasn't only researchers that presented on our science – but also technicians, fieldworkers, and members of our science support teams who are all connected to the end result."

Our annual Strategic Scientific and User Advisory Panel (SSUAP) meeting took place concurrently, meaning representatives were able to connect directly with the wider staff team. SSUAP is made up of international and local experts, whose role is to review GNS Science's performance, future research directions, and capability needs. Panel members shared how much they enjoyed being able to speak with staff at the conference and emphasised how impressed they were by GNS Science's open and engaged culture.

EARLY CAREER STAFF NETWORK CONNECTING SECTOR-WIDE

GNS SCIENCE'S EARLY CAREER STAFF NETWORK (ECSN) GOES FROM STRENGTH TO STRENGTH EACH YEAR, GROWING IN BOTH ITS IMPACT AND ITS MEMBERSHIP. THIS YEAR, THE NETWORK HAD SET ITS SIGHTS ON DELIVERING BENEFIT BEYOND JUST GNS SCIENCE – BY CONNECTING WITH, AND UPLIFTING, EARLY CAREER STAFF ACROSS THE CROWN RESEARCH INSTITUTES (CRIs).

Michelle Cook, GNS Science Energy Materials Scientist and ECSN External Engagement Lead, says that developing cross-CRI connections was an obvious priority for the network given ongoing discussions about how the science sector should operate in the future.

"With programmes of work underway, like Te Ara Paerangi Future Pathways, we felt it was an important time for an early career voice to be involved in sector-wide discussions," says Michelle.

"EARLY CAREER STAFF ARE THE FUTURE LEADERS OF THE SECTOR. HAVING A COLLECTIVE VOICE IN CONVERSATIONS ABOUT WHAT THAT SECTOR LOOKS LIKE – AND HOW IT CAN GROW TO BE AS DIVERSE, INCLUSIVE, INNOVATIVE, AND AGILE AS POSSIBLE – IS INCREDIBLY IMPORTANT."

Setting out to discover what supports were in place for early career staff within the different CRI organisations, we found that GNS Science was one of only two CRIs with established networks.

"The early career perspective in Research, Science, and Innovation (RSI) has typically been led by universities, so it has been great to see such enthusiasm from the CRIs as the group has come together," says Ery Hughes, GNS Science Volcanic Fluid Geochemist and ECSN 22/23 Co-leader.

"Within a couple of months of our first conversations, we were given a chance to pitch the concept of a pan-CRI early career body to the Science New Zealand Board. All the CRI Chief Executives were incredibly supportive, and it has been great to have their backing on this initiative."

The purpose of the Science New Zealand Early Career Member Group is to empower and amplify the early career voice, promote early career connections and initiatives, support advocacy efforts, and act as a reference group on topics relevant to the community it represents. The group has met monthly since its establishment in April 2023.

GNS Science's Early Career Staff Network is a self-identifying group of staff led by a council of its members. Membership of the network and the council comprises a variety of career paths and with members at all of GNS Science's sites.

The network aims to empower early career staff and support their career development. The group is focused on communicating early career staff interests, engaging in the implementation of solutions, and contributing early career voices to both short-term and long-term strategy and planning.

ENVIRONMENT AND CLIMATE

CITIZEN SCIENCE MAPPING METALS IN SOIL

900
SOIL SAMPLES FROM OVER 900 HOMES HAVE BEEN TESTED

28
AUCKLAND CLASSES HAVE BEEN THROUGH THE SOILSAFE KIDS BRANCH

NEW ZEALANDERS LOVE SPENDING TIME IN THEIR GARDENS FEELING THE EARTH BENEATH THEIR FEET. BUT WE DON'T ALWAYS KNOW WHAT CONTAMINANTS MIGHT BE HIDDEN IN OUR SOILS!

Soilsafe – a partnership project between GNS Science and University of Auckland – is inviting people to send in backyard soil samples for free testing for trace metals.

Samples will be run through x-ray fluorescence spectroscopy testing to assess levels of trace metals such as lead, arsenic, cadmium, chromium, copper, manganese, nickel, and zinc. These metals are naturally-occurring, and in high concentrations can impact human health.

Since 2021, soil samples from over 900 homes across nearly every region in the country have been tested. With up to five samples per property, that's 4,318 scoops of soil packaged, sent off and tested in the GNS Science Dunedin XRF laboratory to date.

Results are provided to participants along with information to help them understand their soils. The data is added to the 'Map My Environment' global data visualisation portal, with the privacy of participants and their properties protected.

GNS Science project co-lead, Adam Martin, says that it's vital we build a comprehensive picture of our soils, because they are the foundation of the spaces we live in and grow our food in.

"THE RESULTS HIGHLIGHT THAT THE CONTAMINANT METALS ARSENIC AND LEAD CONTINUE TO BE AN ISSUE FOR NEW ZEALAND GARDEN SOILS. WHEN WE FIND ELEVATED LEVELS OF THESE METALS IN PARTICIPANTS' SOILS WE ALSO PROVIDE FREE ADVICE ON HOW TO MITIGATE THIS SO THEY CAN CONTINUE TO ENJOY THE BENEFITS THEIR SOILS OFFER."

Soilsafe Kids is an education and outreach branch of the project, encouraging kids to think about soil and its everyday relevance. The programme is supported by MBIE's Unlocking Curious Minds, and Te Pūnaha Matatini.

Through school workshops and freely available education resources, Soilsafe Kids aims to demonstrate how soil can be studied through many disciplinary lenses and world views. Workshops have been run with 28 Auckland classes so far and the project has been extended to Northland.

Soilsafe Kids builds upon research undertaken by Soilsafe Aotearoa that explores how our communities value soil.

"Nearly a quarter of the population is under 15, so it's important that we hear from kids about what they value. They ingest more dirt than adults, they have more contact with it, and they're more impacted by contaminants. They've got a lot to contribute," says Sophia W R Tsang, Soilsafe Kids co-lead.

DISCOVER MORE:
soilsafe.auckland.ac.nz

iupui-earth-science.shinyapps.io/MME_Global

ENVIRONMENT AND CLIMATE

SEDIMENT SECRETS INFORM CONSERVATION EFFORTS

A HIDDEN ARCHIVE OF BEECH POLLEN IN LAKE SEDIMENT COULD HOLD THE KEY TO TRANSFORMED PREDATOR CONTROL.

Beech masts offer up a bumper serving of kai for rats, mice, and stoats, fuelling them to breed prolifically and become an even greater threat to our native birds and reptiles. Knowing when a beech mast is approaching is vital for protecting our vulnerable native species, allowing predator control to ramp up to prepare for the influx.

In current conservation management, beech masts – years of extremely heavy seedfall – are predicted by examining triggers such as temperature data and observations of flowering abundance. GNS scientists have pioneered a new approach using sediment records to strengthen our understanding of the environmental drivers of mast seeding.

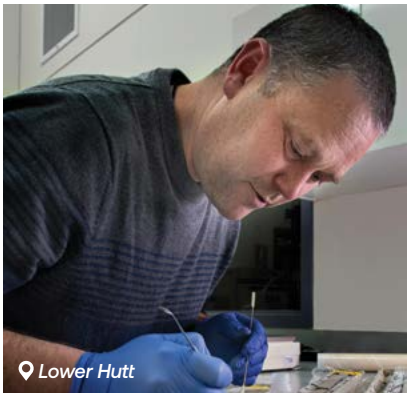
To help predict upcoming mast years, the Department of Conservation uses the environmental relationships observed from seedfall records collected since the late 1960s. While these provide a working model, these datasets of seedfall are gathered over too short of a time to conclusively determine the relationships between climate and mast seeding.

GNS Science Global Change Through Time Programme lead, Joe Prebble, together with ecologists and sedimentologists from GNS Science, Manaaki Whenua, Massey University, and Te Herenga Waka Victoria University of Wellington, examined two sediment cores from the bottom of Lake Ōhau. The sediments, deposited over the last 150 years, acted as a proof of concept for using pollen deposited in geological records as a proxy record of masting.

"AS THE SEDIMENT FALLS TO THE LAKEBED IT FORMS ANNUAL LAYERS WHICH CAN BE READ LIKE CHAPTERS IN A BOOK. WE LOOKED FOR PEAKS IN BEECH POLLEN TO INDICATE MAST YEARS."

The team analysed 3-4 thin (2.5mm) slices of the sediment core for each year, and measured pollen abundance from two genera of Southern Beech trees, *Fuscospora spp.* and *Lophozonia spp.* They examined the data alongside corresponding temperature records.

Initial results demonstrated a strong correspondence between pollen mast frequency observed in the samples, and the mast frequency predicted by the existing climate-masting relationships derived from seedfall records, particularly for *Fuscospora spp.*



Joe Prebble examines one of the Lake Ōhau cores

Prebble says the results show the potential for using this approach to supplement existing seedfall records, and to significantly enhance our understanding of the environmental cues for mast seeding.

"We've successfully demonstrated that these sediment knowledge libraries deep under Lake Ōhau hold valuable ecological insights. Longer records of this type could help fine-tune forecasts of masting years, which ultimately is a win for our native taonga species."

"To the best of our knowledge, the extraordinary value of these lake-borne archives for this type of ecological research has not been recognised previously. It's exciting to be able to use paleo-environmental research techniques to support the Department of Conservation's goal of a Predator Free Aotearoa by 2050."

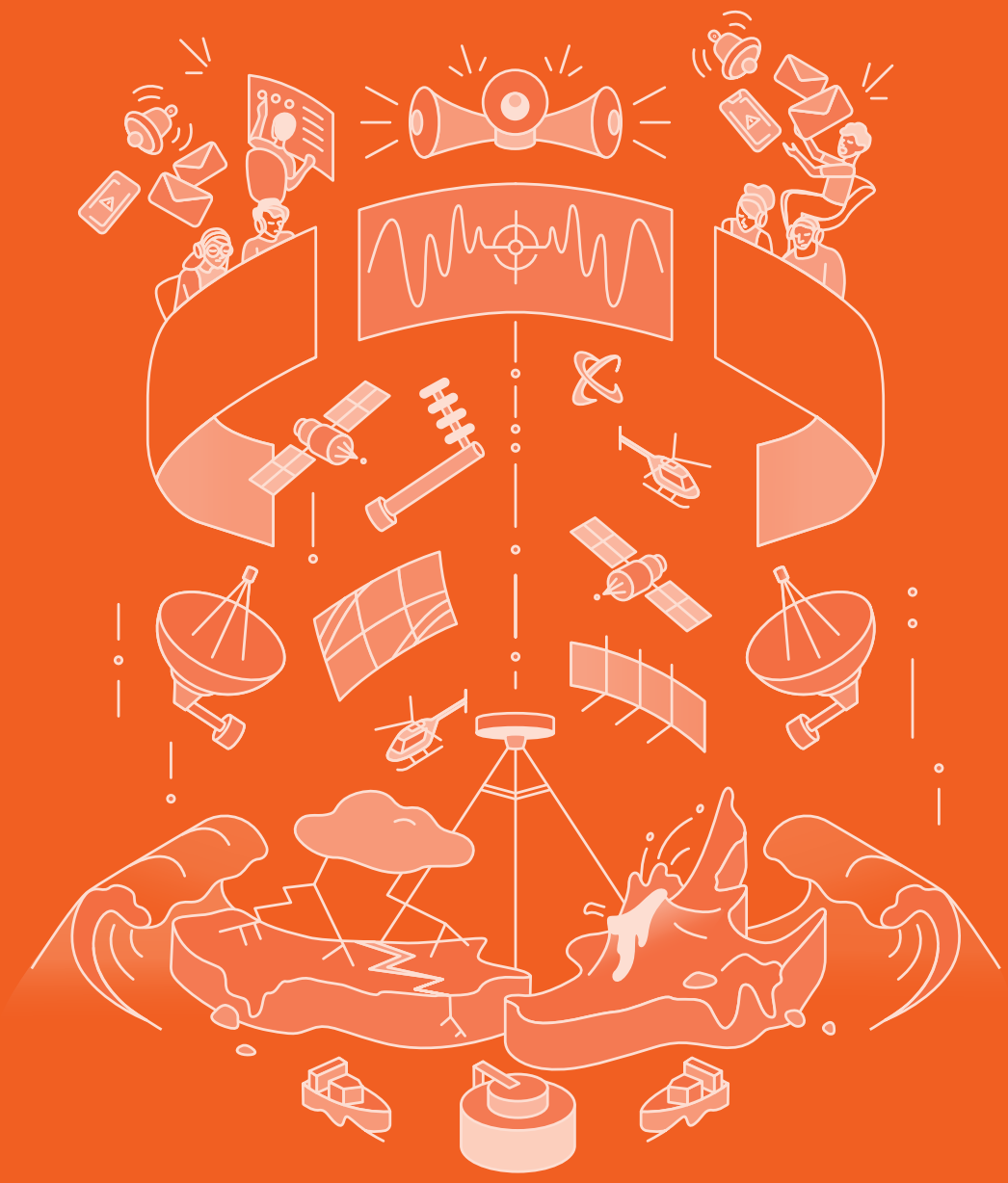
1960
SEEDFALL RECORDS HAVE BEEN COLLECTED SINCE THE LATE 1960S

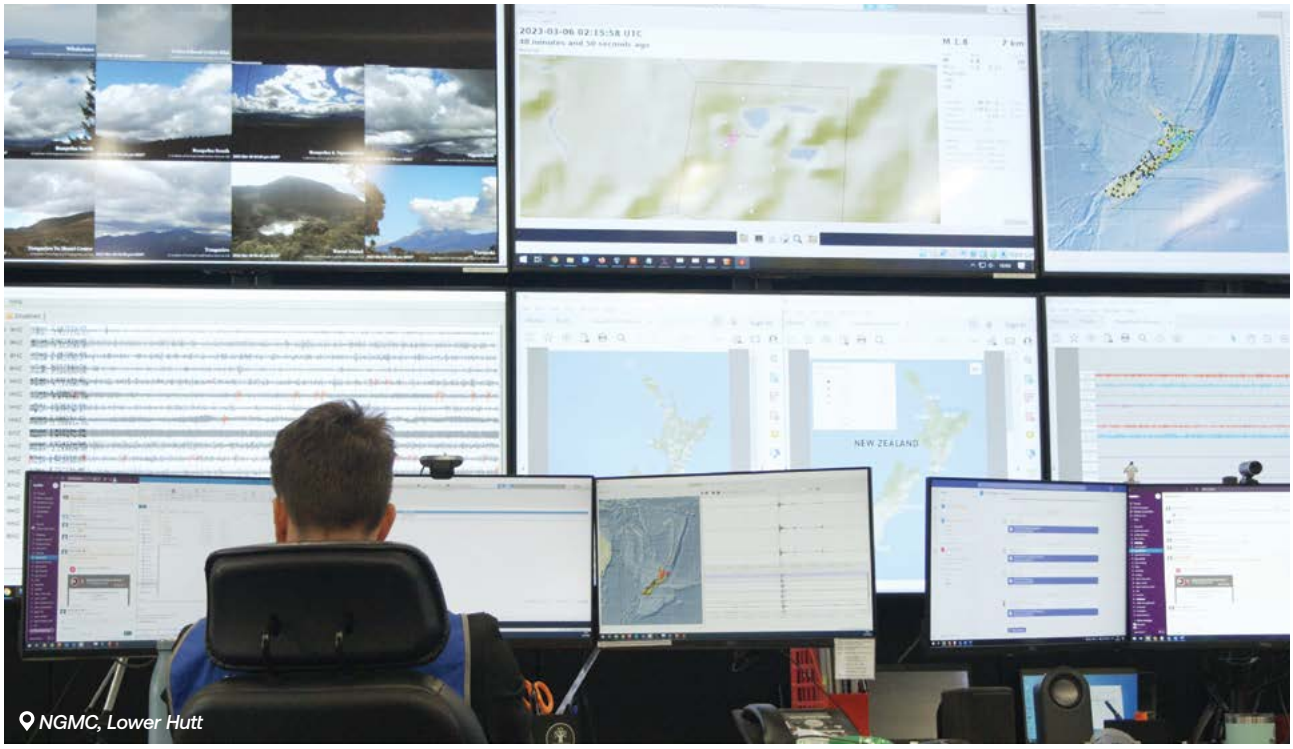
2
SEDIMENT CORES FROM THE BOTTOM OF LAKE ŌHAU HAVE BEEN EXAMINED

DISCOVER MORE:
journals.sagepub.com/doi/10.1177/09596836221114292

NATURAL HAZARDS AND RISKS

MONITORING THE MOTU





NGMC, Lower Hutt

NEW ZEALANDERS CAN REST A LITTLE EASIER, KNOWING THAT EVERY MINUTE OF EVERY DAY, GNS SCIENCE IS WATCHING OVER US.

Aotearoa New Zealand has a unique geographical and geological place in the Pacific, along the collision zone of two of the Earth's major tectonic plates. Whilst this gives us our stunning landscapes, it also puts us at risk from natural hazards such as earthquakes, tsunami, volcanoes, and landslides.

To help mitigate the risks and enable government, councils, and communities to plan for, respond to, and recover from natural hazard events, GNS Science operates a network of over 9,000 instruments and supporting equipment.

The monitoring technology is deployed in more than 700 locations across the motu – in lighthouses, on farmland, along the coast, under oceans and lakes, up mountains, on buildings and bridges, and even on active landslides.

"Our monitoring networks, including GeoNet, alongside our science expertise, work together in a powerful partnership to deliver science information and advice," says Geohazards Monitoring Manager, Bruce Girdwood.

"It works quickly to provide information and reassurance to people when they're jolted awake by an earthquake at 2.00am. It provides data to our scientists and enables them to share real-time scientific analysis and forecasts with first responding agencies, like NEMA, to help guide emergency response. And it helps direct the efforts and allocation of Civil Defence, council, and recovery agency resources."

The public also contributes to the nation's data collection efforts by recording earthquake 'felt reports' on the GeoNet app or 'dobbing in a landslide' on the GNS Science website.

Landslides are largely unpredictable and much of our monitoring and research is conducted after they have occurred. However, our experts are currently developing landslide forecasting models that will, in the not-too-distant future, enable us to model the probability of landslides in certain regions, which will support regional authorities and infrastructure providers to better plan, construct and build resilience.

9000
THE MONITORING NETWORK IS MADE UP OF OVER 9000 INSTRUMENTS AND EQUIPMENT

700
LOCATIONS ARE BEING MONITORED ACROSS AOTEAROA

Tongariro National Park

"ENGAGING NEW ZEALANDERS IN PRACTICAL WAYS ABOUT THE RISKS POSED BY OUR NATURAL HAZARDS ENABLES THEM TO DRAW A LINK BETWEEN SCIENCE AND SAVING LIVES. IMPORTANTLY, WE ALSO KNOW THAT THE MORE INFORMED AND KNOWLEDGEABLE THE PUBLIC IS ABOUT RISK, THE BETTER THE DECISIONS THEY WILL MAKE IN TIMES OF CRISIS," BRUCE SAYS.

"In a country prone to a range of natural hazards, the investment the government makes in our data and science pays measurable dividends."

And it's not all about earthquakes and landslides.

With two thirds of Aotearoa's population living within five kilometres of the coast, many of our communities are vulnerable to tsunami. GNS Science operates a deep-ocean monitoring network (DART) for NEMA, which monitors potential tsunami waves across the Pacific. Supporting the DART network is our Tsunami Coastal Gauge network, which can detect tsunamis arriving at Aotearoa New Zealand's coasts.

"Our tsunami network and the knowledge we gain from it means we can provide timely and accurate advice to NEMA before a tsunami arrives, which is crucial to saving lives and reducing economic and societal disruption," says Bruce.

Advancing science is adding considerable weight to our tsunami detection and assessment capability with new products being introduced, like those developed by the Rapid Characterisation of Earthquake and Tsunami (RCET) programme. Over the next year, exciting new science tools, like Shaking Layers, will be added to our hazardscape monitoring tool kit.

Aotearoa New Zealand is home to eight active volcanoes, and several more that have the potential to become active in future. GNS Science's Volcano Monitoring Group tracks the current state of our volcanoes using visual observations, chemical analysis, air pressure sensors, seismic and acoustic monitoring, and on-site and remote assessments.

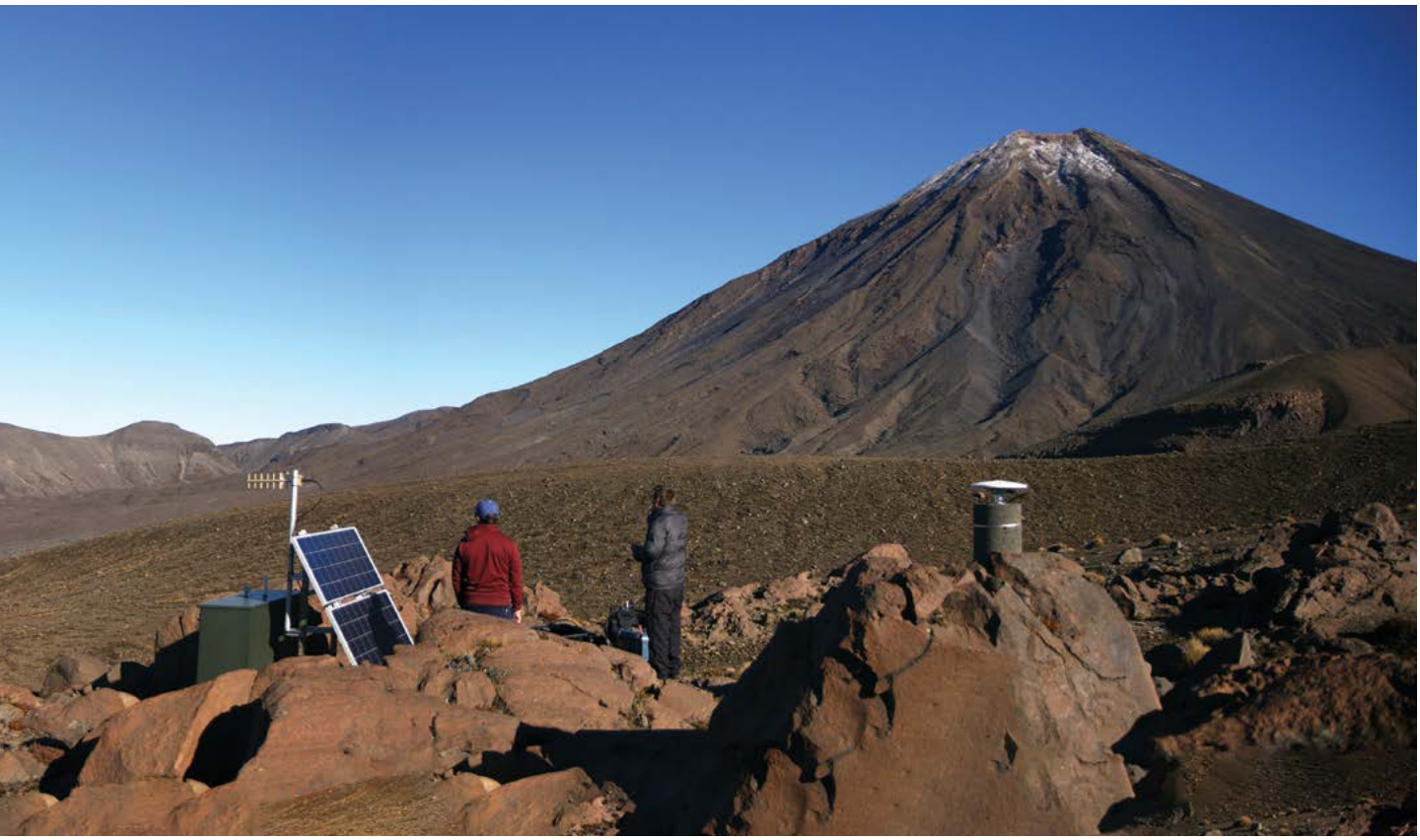
"No one can never predict when an eruption will occur," Bruce explains. "But through a combination of detailed research and 24/7 monitoring, GNS scientists can glean valuable insights into past eruptions, forecast and model future events, and inform disaster management and evacuation plans."

Our extensive monitoring programme, coupled with world-leading scientific expertise, informs and influences the development of government policy, local and regional council resource planning and consents, and our national emergency response.

By making natural hazard and risk information widely accessible, GNS Science promotes and builds community awareness, improves preparedness, and helps to increase national resilience.

We're proud of the powerful, positive partnerships that drive this work with Toka Tū Ake EQC, Toitū Te Whenua Land Information New Zealand, Hīkina Whakatutuki Ministry of Business Innovation and Employment and Te Rākau Whakamarumaru The National Emergency Management Authority.

DISCOVER MORE:
gns.cri.nz/our-science/natural-hazards-and-risks



BY THE NUMBERS

12
SEAFLOOR TSUNAMI SENSORS IN THE PACIFIC OCEAN

8
ACTIVE VOLCANOES

18
TSUNAMI GAUGES ALONG NEW ZEALAND'S COASTLINES

12
VOLCANO SURVEILLANCE CAMERAS CAPTURING IMAGES EVERY 10 MINUTES

700+
LOCATIONS ACROSS THE MOTU

9000+
MONITORING INSTRUMENTS AND EQUIPMENT

24/7
MONITORING OF GEOHAZARDS

20,000
EARTHQUAKES RECORDED ANNUALLY

NATURAL HAZARDS AND RISKS

PREPARING AOTEAROA FOR EARTHQUAKES

Te Whanganui-a-Tara waterfront

THE NATIONAL SEISMIC HAZARD MODEL (NSHM) IS A CRITICAL ELEMENT OF AOTEAROA NEW ZEALAND'S SCIENCE INFRASTRUCTURE, INFORMING TECHNICAL STANDARDS FOR ENGINEERING DESIGN AND CONTRIBUTING TO EARTHQUAKE RISK MANAGEMENT RELEVANT TO INSURANCE, PLANNING AND EMERGENCY RESPONSE.

An important part of New Zealand's hazard-scape toolkit, the NSHM provides an estimate of the likelihood and strength of future earthquake ground shaking at any given site in New Zealand. It considers how different parts of the country might behave in the event of large magnitude earthquakes.

Working alongside MBIE, Toka Tū Ake EQC, NEMA, engineers, and universities, GNS Science incorporated the latest international science into the NSHM revision, and added data and knowledge gained from Aotearoa New Zealand's most significant recent earthquakes, notably the Canterbury earthquake sequence and the Kaikōura earthquakes.

"The NSHM is a tool that brings together all the information we have about our earthquake hazards," says NSHM Project Lead, Dr Matt Gerstenberger.

"IT IS CRITICAL TO HAVE AN UP-TO-DATE UNDERSTANDING OF THE SEISMIC HAZARDS FACING NEW ZEALAND TO HELP US MANAGE THE RISKS EARTHQUAKES POSE TO PEOPLE, PROPERTY AND THE ENVIRONMENT."

The NSHM incorporates knowledge acquired from diverse research fields, ranging from statistics, paleoseismology (study of historic earthquakes), geodesy (study of deformation of the Earth's surface), seismology (study of earthquake occurrence and shaking) and geophysics (study of the physics properties and processes of the Earth), through to engineering seismology (study of the interface of earthquake occurrence and the built environment).

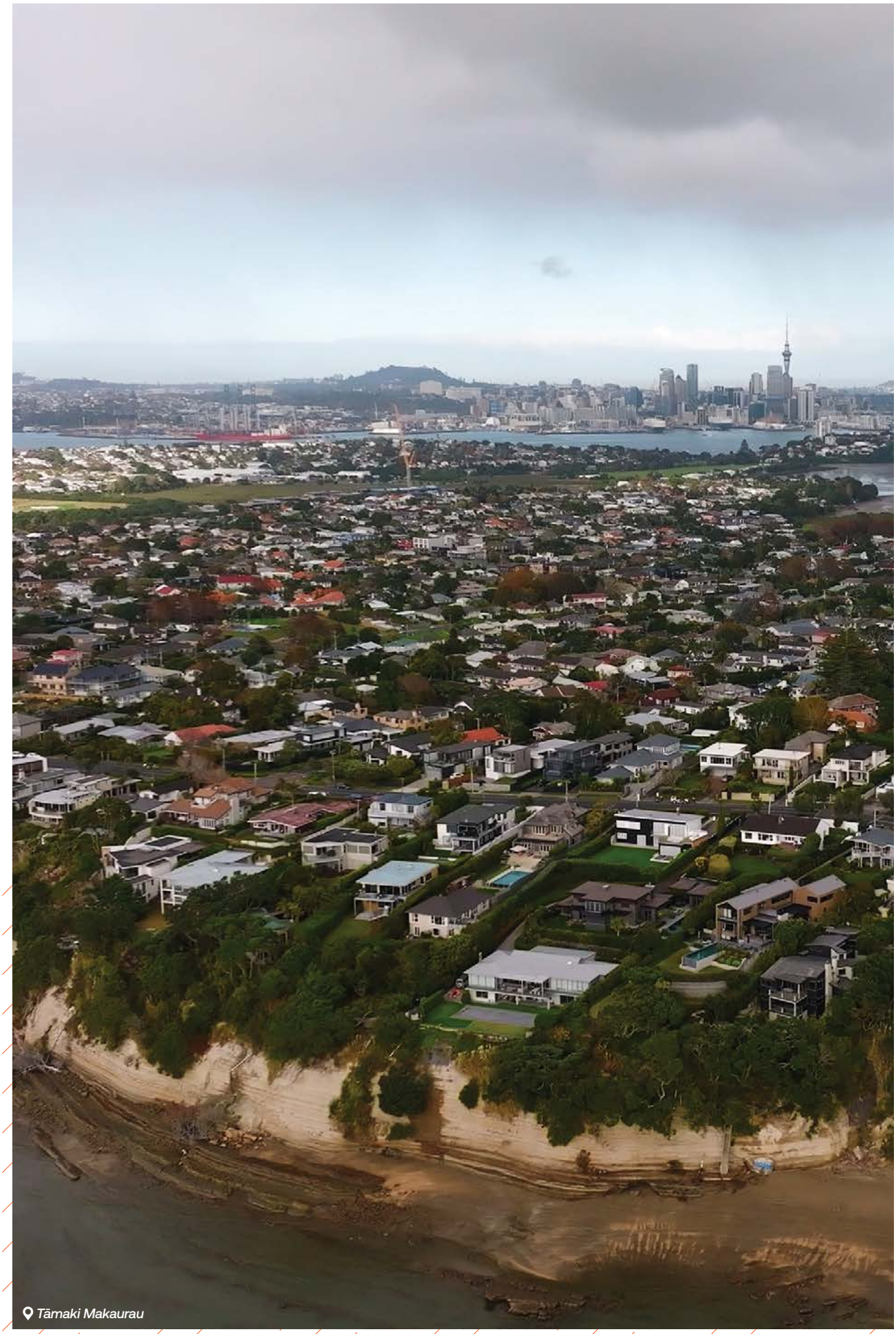
That wealth of information comes together in the NSHM, which paints a robust picture of significantly improved understanding. We now know the forecast hazard has increased across much of the country and that knowledge is a gift, providing ample opportunity for Aotearoa New Zealand to better prepare.

THE MORE WE KNOW, THE BETTER WE CAN POSITION OUR COMMUNITIES TO COPE WITH FUTURE EARTHQUAKES AND THE IMPACTS THEY MAKE ON OUR SOCIETY, OUR INFRASTRUCTURE, AND OUR ECONOMY.

The NSHM is widely used by government, councils, infrastructure providers, engineers and insurance companies. It informs the Building Code, supports more efficient design of societal infrastructure, sets the standard for seismic resilience for dams, roads and bridges, impacts local government resource management and land-use planning, and supports emergency management, business continuity planning, and community resilience.

"It's our job now to integrate that knowledge with the people who can use the information to help New Zealanders be as safe and prepared as they can be," Gerstenberger says.

DISCOVER MORE:
gns.cri.nz/nshm



Tāmaki Makaurau

TE IKA-A-MĀUI

THE NORTH ISLAND'S DIVERSE GEOLOGICAL FEATURES, ACTIVE TECTONIC PLATE BOUNDARIES, GEOTHERMAL RESOURCES AND VOLCANIC ACTIVITY PROVIDE A TREASURE TROVE OF RESEARCH OPPORTUNITIES FOR GNS SCIENTISTS.

WORKING ALONGSIDE IWI, COMMUNITIES AND INDUSTRY, WE RESEARCH, MONITOR AND EXPLORE THE ISLAND'S GEOLOGICAL HAZARDS AND RESOURCES.

IMPACT CELEBRATED AT EXCELLENCE AWARDS

EVERY YEAR WE CELEBRATE OUTSTANDING STAFF ACHIEVEMENTS AT OUR GNS SCIENCE EXCELLENCE AWARDS. IT'S OUR CHANCE TO RECOGNISE THE VERY BEST OF OUR SCIENCE IMPACT, AND OF GNS SCIENCE PEOPLE LIVING OUR VALUES OF MANAAKITANGA, CONNECTED, INSPIRED AND EMPOWERED.

Staff are nominated by their peers, with a panel of senior staff and executive leaders selecting the winners. This year the awards were celebrated at a series of events across our sites, and staff gathered to watch a live-streamed video event featuring the winners and their nominators.

Winners in our Early Career, Team, and Lifetime Achievement categories were also our Science New Zealand Award-winners in 2022.

EXCELLENCE IN MAKING A DIFFERENCE: CONNECTED

GNS Science Website Project Team – for delivering a new website that is a modern and dynamic reflection of our organisation, allowing us to better connect with our partners, stakeholders, and the public.

"THE NEW WEBSITE HAS REALLY HELPED BOTH INTERNAL AND EXTERNAL CONNECTIVITY – BETWEEN PROJECTS, BETWEEN GNS SCIENCE AND THE WORK WE DO FOR THE PUBLIC, FOR OUR STAKEHOLDERS, AND FOR ANYBODY THAT'S LOOKING FOR INFORMATION OR TO CONNECT WITH GNS SCIENCE"
– ROSE MACFARLANE, FORMER GM PEOPLE AND CULTURE.

Simone Keough, Lesley Wild, Jeff Lyall, Nick Kirkman, Nikki Hawkey, Jeremy Houltham, Deanne Houghton

EXCELLENCE IN EARLY CAREER ACHIEVEMENT

Emily Warren-Smith – for her creative and insightful integration of geophysical and geological data to reveal entirely new insights into earthquake, slow slip, and plate boundary processes.

"EMILY IS MAKING A GLOBAL NAME FOR HERSELF BY BECOMING A SPECIALIST IN UNDERSTANDING BIG EARTHQUAKES BY STUDYING VERY, VERY SMALL EARTHQUAKES"
– JOHN TOWNEND, TE HERENGA WAKA VICTORIA UNIVERSITY OF WELLINGTON.

8
EXCELLENCE AWARD CATEGORIES FOR 2023

37
STAFF REGOGNISED BY AWARDS

GNS scientists installing seismic monitoring equipment

EXCELLENCE IN HEALTH AND SAFETY

National Isotope Centre Chemical Store Management Team led by Valerie Stucker – for voluntarily taking on the management of the chemical stores at our Gracefield site and making incredible strides in processes, training, handling, and tracking of hazardous substances.

"FUNDAMENTALLY, GNS SCIENCE IS A MUCH SAFER PLACE BECAUSE OF THE WORK THIS TEAM HAS DONE IN HAZARDOUS SUBSTANCES"
– STEVE LOGAN, GNS SCIENCE HEALTH AND SAFETY BUSINESS PARTNER.

Valerie Stucker, Mus Hertoghs, Jannine Cooper, Siriluck Tesana, Te Aomania Te Koha, Taylor Ferrick, Tyler Heath, Jacob Leath, Roger Tremain, Joan Fitzgerald, Luana Alves.

EXCELLENCE IN VISION MĀTAURANGA

Tūhara Papatūānuku Geo Noho Team – for their work with Far North REAP and Te Aho Tū Roa Programme to co-design and co-deliver a programme that combines mātauranga Māori, te reo Māori, and Geoscience to help intermediate-aged students learn about the environment and the world.

"THE THING I TAKE A LOT OF HEART FROM WITH GEO NOHO IS THE STRENGTH OF THE RELATIONSHIPS WE HAVE WITH COMMUNITY ORGANISATIONS IN THE FAR NORTH. I THINK OF OUR DIFFERENT CONTRIBUTIONS LIKE A NET – THE CONCEPT OF KUPENGA – SO THE MORE THREADS YOU WEAVE TOGETHER, THE STRONGER THE NET BECOMES"
– KYLE BLAND, GNS SCIENCE SENIOR GEOLOGIST.

Kyle Bland, Sonja Bermudez, Joe Prebble, Jess Hillman, Malcolm Arnot, Courtney Sanson, Shontelle Nahona.

EXCELLENCE IN MAKING A DIFFERENCE: EMPOWERED

Elisabetta D'Anastasio – for empowering everyone in the GeoNet programme to push themselves to learn, try new things, and deliver their best.

"ELISABETTA NEVER SHIES AWAY FROM THE DIFFICULT PROBLEMS WE ARE TRYING TO SOLVE, BUT AT THE SAME TIME SHE WILL ALWAYS APPROACH THEM IN A WAY THAT HELPS THE TEAM GROW AND GAIN EXPERTISE"
– JONATHAN HANSON, SCIENCE AND OPERATIONS TEAM LEADER.

Wellington Airport

EXCELLENCE IN TEAM ACHIEVEMENT

NZ SeaRise Vertical Land Movement Team – for delivering the highest resolution map of country-wide vertical land movement ever produced, allowing for bespoke sea level rise projections every two kilometres around our coastline.

"IT'S BEEN A REAL PRIVILEGE AND EYE OPENER TO WORK ACROSS DIFFERENT DISCIPLINES AND SEE HOW THE WORK WE'RE DOING NOW CONTRIBUTES TO A MORE SUSTAINABLE FUTURE"
– IAN HAMLING, GNS SCIENCE INSAR SCIENTIST.

Sigrún Hreinsdóttir, Ian Hamling, Kate Clark, Nicola Litchfield, Richard Levy

EXCELLENCE IN MAKING A DIFFERENCE: INSPIRED

Experimental Geochemistry Laboratory – for delivering a lab service that is unique in the world and fundamental in solving some of the biggest challenges the geothermal industry faces.

"WE DO STUFF THAT NO ONE ELSE DOES, SO PEOPLE ARE COMING TO US WITH PROBLEMS FOR WHICH THEY DON'T HAVE A SOLUTION. THERE IS NO MANUAL OF INSTRUCTIONS FOR US TO FIGURE OUT HOW TO DO THESE EXPERIMENTS!"
– LUCJAN SAJKOWSKI, GNS SCIENCE GEOTHERMAL CHEMIST.

Bruce Mountain, Lucjan Sajkowski, Peter Rendel, David Byrne

EXCELLENCE IN LIFETIME ACHIEVEMENT

Rob Funnell – for his substantial legacy of technical expertise including sedimentary basin modelling and carbon capture and storage, as well as his empowering leadership.

"I THINK AN ENDURING LEGACY OF ROB'S TIME AT GNS WILL BE IN THE MANY STAFF THAT HE LED OVER THE YEARS. HE INSPIRED, MOTIVATED, AND INFLUENCED STAFF, BOTH IN THEIR TECHNICAL EXPERTISE AND THEIR GROWTH AS INDIVIDUALS"
– RICHARD SYKES, GNS SCIENCE ORGANIC GEOCHEMIST.

GROWING LEADERSHIP ACROSS GNS SCIENCE

GNS SCIENCE'S *TŪHONO* LEADERSHIP PROGRAMME CONTINUES TO GROW AND DEVELOP LEADERS ACROSS OUR ORGANISATION.

It's a bespoke programme, developed and run by Dr Peter Blyde and tailored to meet GNS Science's specific needs. Every GNS Science staff member is able to put themselves forward for the programme, and it continues to be very well subscribed, with all seven courses in 2022/23 fully booked.

A wide range of staff have participated, including people and project leaders and those just starting out in their career and leadership journey. In total, 128 GNS Science staff have benefitted from the programme.

Everyone at GNS Science is a leader in one way or another, contributing to the success of our science and the organisation. The programme is based on a three-strand leadership framework: technical leadership, performance leadership, and change leadership.

Palynologist, Joe Prebble says that thinking about three 'flavours' of leadership has been useful.

"Rather than thinking about leadership as something that you either do or don't do, *Tūhono* prompts you to think differently about where and how you show leadership, and how you perceive the leadership of others."

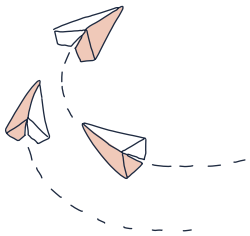
Valerie Stucker, Earth and Environmental Science Laboratories Manager and another *Tūhono* graduate, said that the idea of technical leadership really resonated with her, especially given that each of us are leaders in our own fields of expertise.

"LEADERSHIP IS NOT ABOUT A TITLE OR A ROLE, IT'S ABOUT YOUR CONTRIBUTION. WHAT YOU CONTRIBUTE, AND HOW YOU HELP OTHERS CONTRIBUTE. I THINK A LOT OF PEOPLE AROUND GNS SCIENCE ARE DOING LEADERSHIP ALL THE TIME, AND THEY JUST DON'T SEE IT AS LEADERSHIP."

"*Tūhono* got me thinking about how you show up as a leader, and the planning and the reflection involved in doing that well. I've found that taking time to ask myself about what kind of contribution I expect of myself, and what I expect of others, has been helpful, especially in moments when I'm less sure of the right approach," says Joe.

At GNS Science, leadership development goes beyond personal development. *Tūhono* focuses on equipping our people with the tools they need to deliver the best possible science outcomes and contribute fully to organisational development. The programme uses a blended learning approach that incorporates 'real world' projects – driving change and innovation across science, processes, and all areas of organisational development.

3
TŪHONO IS BASED ON A THREE-STRAND LEADERSHIP FRAMEWORK



128
STAFF FROM ACROSS GNS SCIENCE HAVE PARTICIPATED IN TŪHONO

ENSURING A CAREER PIPELINE FOR MĀORI SCIENTISTS


Gracefield


Avalon

WE'RE BUILDING PATHWAYS THAT LOWER BARRIERS FOR YOUNG MĀORI TO ENTER THE SCIENCE SECTOR.

Our Ahunuku scholarship programme – jointly supported by GNS Science and Te Herenga Waka Victoria University of Wellington – provides university students of Māori descent with an opportunity to enhance their skills and gain valuable experience within Earth sciences, with the guidance and support of GNS Science experts.

Ahunuku scholarships offer students a stipend while they participate in a defined research project that gives them valuable work experience and a network of contacts. In 2022/23 we hosted three Ahunuku Scholars, working in projects in Energy Futures, Environment and Climate, and Māori Engagement/ Communication. They joined us over the summer break, alongside a wider group of 32 summer interns.

GNS Science Manager of Māori Strategy and Partnerships, Mereana Wilson-Rooy, says it's particularly exciting when our Ahunuku scholars transition from their academic studies to a science career and employment with us after the end of their scholarship programme.

"We're thrilled to have had two Ahunuku scholars join the GNS Science whānau full time as Lab Technicians. We've had others continue in part-time work with us as they've completed their studies."

"IT'S ALWAYS GREAT TO SEE THE ONGOING IMPACT OF THIS PROGRAMME, PARTICULARLY WHEN IT MEANS GNS SCIENCE IS ABLE TO BOTH FOSTER EMERGING TALENT AND DEVELOP OUR OWN RESEARCH SKILLS.".

Te Aomania Te Koha joined GNS Science as an Ahunuku scholar in 2019. She's now been a full-time member of the Geological Research Labs and Collections team for two years.

Te Aomania says the scholarship really encouraged her to pursue a career in science "While studying chemistry at university, I always felt like the odd one out, being Māori in the science faculty. The learning style wasn't always suited to me, I couldn't relate to any of my teachers or classmates, and I felt like I didn't really belong. To me, the Ahunuku scholarship was a clear indication that GNS Science was making an effort to hold space for Māori and support our journey through the science sector."

ENERGY FUTURES

UNLOCKING THE POTENTIAL OF GREEN HYDROGEN

GNS SCIENCE'S FIRST SPIN-OUT COMPANY – BSPKL – REPRESENTS AN EXCITING STEP TOWARDS A NET-ZERO CARBON FUTURE, MEANINGFULLY POWERED BY GREEN HYDROGEN.

Green hydrogen is a safe and clean fuel source that can accelerate the delivery of Aotearoa's net-zero carbon ambitions. But, in the current global context of supply chain issues, rising costs, and shortages of raw minerals, its affordability and availability faces a number of challenges.

Bspkl is set to support the transition to a low-carbon future through its innovative approach to manufacturing Catalyst Coated Membrane (CCM) for hydrogen electrolysers, helping to accelerate hydrogen's widespread adoption as a clean energy source.

Bspkl 'spins-out' the first of GNS Science's world-class green hydrogen expertise and innovation, making the technology accessible for application in real-world solutions. It's supported and funded by WNT Ventures and the wider WNT Group, as well as Investible, and other investors. At its helm are Jérôme Leveneur, Ion Beam Materials Scientist and Chief Technical Officer of Bspkl, and Christina Houlihan, Chief Executive.

Sheena Thomas, GNS Science Commercial and Business Partnerships Manager, says the Bspkl technology is a big step forward in unlocking the potential of green hydrogen as a carbon-zero energy source.

"Getting to carbon-zero is one of the most pressing challenges of our time, and GNS Science is well positioned to support Aotearoa New Zealand's transition to a sustainable energy future.

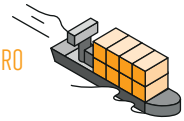
"ACCORDING TO THE INTERNATIONAL ENERGY AGENCY (IEA), GREEN HYDROGEN DEMAND IS PROJECTED TO ALMOST DOUBLE TO 180MT BY 2030. RIGHT NOW THERE IS ALMOST 100MT OF HYDROGEN BEING USED EVERY YEAR THAT IS MADE FROM FOSSIL FUELS, SO IT'S AN URGENT ISSUE TO ADDRESS. THE BSPKL TECHNOLOGY ACCELERATES REPLACING THAT WITH GREEN HYDROGEN, BY ENABLING ENOUGH ELECTROLYSERS TO BE PRODUCED TO MEET THE DEMAND."

Peter Benfell, General Manager Business Services, says the Bspkl technology is built on decades of GNS Science materials science expertise and innovation.

"GNS Science will play a major role in enabling New Zealand's transition to a carbon-zero future, and Bspkl is a brilliant example of the impact our green hydrogen programme of work is generating.

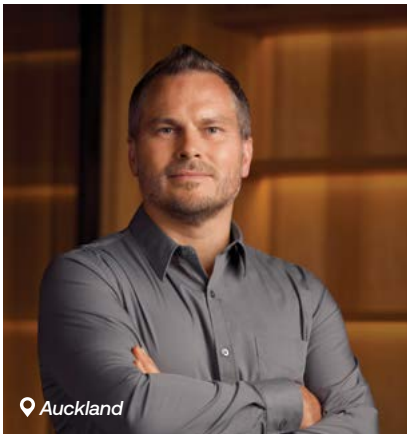
"Our organisation has a legacy of world-class materials science research and discovery, and the successful launch of Bspkl is a credit to the many GNS Science experts that have contributed to this innovation".

BSPKL IS A STEP TOWARDS A NET-ZERO CARBON FUTURE FOR AOTEAROA



ENERGY FUTURES

INNOVATING BETTER MATERIALS TOGETHER



Kane Alwar

ADVANCING THE DEVELOPMENT AND USE OF ENERGY-EFFICIENT MATERIALS IS PIVOTAL TO ACHIEVING A RESILIENT, NET-ZERO CARBON ENERGY SYSTEM. GNS SCIENCE IS WORKING WITH TECHNOLOGY LEADERS TO MEET THE CHANGING NEEDS OF OUR COMMUNITIES, INDUSTRIES, AND GOVERNMENT.

Working in partnership with technology leaders, we can bridge the gap between research and market application. These valuable relationships help us prioritise our research efforts, and inform practical science solutions that are useful, usable, and used by consumers and industry.

Fisher & Paykel Appliances (F&P) is demonstrating its commitment to de-carbonisation through its Carbon Zero SmartHome R&D Institute. It's a connection point for experts from across the motu and the world to collaborate on technology and innovation needed to drive positive, sustainable change.

With the help of the New Zealand Product Accelerator (NZPA), F&P put out a call for help with its first 'research challenge' – making a step change in thermal insulation performance, with a view to decarbonising and increasing energy efficiency in Aotearoa New Zealand homes.

GNS Science's in-house expertise was a vital component of this challenge. We are leading several different streams of work with F&P to investigate the fundamentals of heat-transfer, and to explore the application of those fundamentals to temperature controlled appliances that have reduced energy consumption and a lower carbon footprint.

Work on the research challenge is supported by the NZPA and a wider research team of post-doctoral, PhD, Masters, and undergraduate students.

F&P's Executive VP CarbonZero Transition and R&D, Kane Alwar, says the project is a great example of the potential to extend F&P's appliance knowledge and engineering innovation with GNS Science's fundamental materials science expertise.

"As part of our carbon-zero goal, this 'research challenge' targets a 90% improvement in insulation effectiveness. It would enable 50% lower refrigerator and oven energy use and has wider potential across home construction and industrial insulation.

"We're looking forward to more opportunities to partner with the research community and create the technologies we all need for a carbon-zero future."

GNS Science's Project Lead and Energy Materials Scientist, Murray McCurdy, says the breadth of the research and its possible applications is incredibly exciting.

"THIS RESEARCH SPANS THE SCALES FROM PLACEMENT OF INDIVIDUAL ATOMS THROUGH TO APPLIANCE MANUFACTURING. ALONGSIDE APPLIANCE INNOVATIONS, IT WILL LIFT OUR CAPABILITY IN NEW ZEALAND TO DELIVER WORLD-LEADING ENERGY EFFICIENCY RESEARCH."

In addition to the team's focus on pursuing fundamental science breakthroughs, it is also seeking to apply the lessons as they go – enabling the project to generate short-term value while supporting the medium- and longer-term successes.

90%
THIS 'RESEARCH CHALLENGE' TARGETS A 90% IMPROVEMENT IN INSULATION EFFECTIVENESS

50%
NEW MATERIALS DEVELOPED WOULD ENABLE 50% LOWER REFRIGERATOR AND OVEN ENERGY USE

TAKING ACTION TO CURB CARBON EMISSIONS

AT GNS SCIENCE, OUR CUTTING-EDGE RESEARCH SUPPORTS ENVIRONMENTAL STEWARDSHIP AND THE PURSUIT OF NATIONAL CARBON REDUCTION GOALS.

We uncover the secrets of past climates to drive climate change mitigation and adaptation actions for the future. We proudly call ourselves the 'Energy CRI' because we're leaders in Aotearoa New Zealand's quest for a sustainable, low-carbon energy future.

But we know it's not enough to just be the experts. We're taking action and driving change in our own backyards through our own commitment to carbon reduction.

Being a Crown Research Institute (CRI), GNS Science is not part of the Government's Carbon Neutral Government Programme (CNGP), but we are committed to the CNGP, SBTi, and Toitū requirements. The Toitū carbonreduce program is a world-leading certification scheme that helps businesses and organisations accurately measure their direct and indirect greenhouse gas emissions.

Following our enrolment in the Toitū programme in 2020, we undertook our first 'carbon audit' in March 2021. We then committed to reducing our net carbon emissions by 4% per annum, with a goal to achieve a cumulative 20% decrease from our baseline year (2018/19) by 2025.

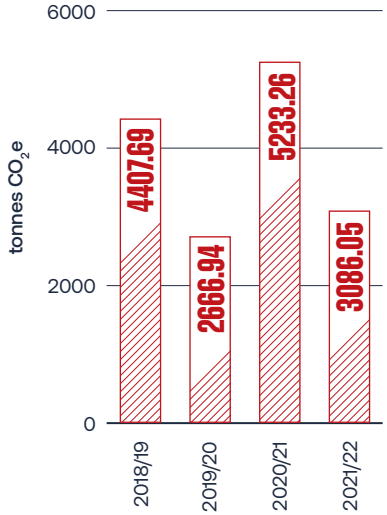
We release an annual Toitū carbonreduce Emissions Summary that demonstrates our efforts and progress towards reaching our reduction targets. The inaugural report is published on our website.

We don't just focus on the big picture; we zoom in on every facet of our organisation and operations. From our research sites to our laboratories, from our staff's daily commutes to their time spent working from home, and even our fieldwork, we leave no stone unturned.

Our road to carbon reduction hasn't been without an occasional curveball. Covid-19 kept us at home, and our lack of air travel in 2019/20 had a notable impact on our emissions. We've also faced one-off challenges like gas and refrigerant leaks in 2020/21.

We're proud to say that we now hold four consecutive years of certification from Toitū's carbonreduce programme. With our sights set on 2025, we're well on track to deliver on our carbon reduction goals. Our commitment to the environment isn't just a scientific endeavour; it's a promise to the planet. We're committed to forging a greener, more sustainable future for all.

GNS SCIENCE'S TOTAL GROSS EMISSIONS FOR 2018-2022



EMBEDDING NEW SYSTEMS TO SUPPORT OUR SCIENCE

GNS SCIENCE'S NEW ENTERPRISE MANAGEMENT SYSTEM, WORKDAY, GIVES US THE TOOLS TO DRIVE IMPROVEMENTS TO WORKFLOW ACROSS THE ORGANISATION BY BRINGING TOGETHER OUR PEOPLE, OUR PROJECTS, AND OUR FINANCIAL INFORMATION AND SYSTEMS.

Workday went live on 1 July 2022, with a second phase of the system – learning and talent management – launched in March 2023. The implementation was done in partnership with the Institute of Environmental Science and Research (ESR), as co-tenants, which reduced implementation costs and ongoing licensing fees for both organisations.

"Workday is a powerful tool that puts the information we need at our fingertips and connects our people and our workflow in a single system," says Peter Benfell, Interim General Manager Business Services.

"It sits at the heart of our ability to work seamlessly across GNS Science to deliver the best possible science. Embedding the system well had its challenges, but we're continuing to drive improvements to the system and our processes within it".

Phase two delivered new systems that support our people's learning and development. These tools allow staff to manage their career planning, learning, training, and goal setting process.

Our people are able to access and book a wide variety of training courses at the click of a button, and record where they've invested time in learning and professional development. They can also manage a career profile that reflects their skills and experience, and provide insights for leaders to assess capability, development, and succession opportunities.

Importantly, the new system gives us one standardised place to do goal setting and performance reviews across the business. This will make it easier for our people and leaders to get the best out of the process, says Suzi Paese, GNS Science Human Resources Manager.

"Staff are undertaking their goal setting in Workday for the first time this financial year, and we're already hearing positive feedback from them about how easy it is to use."

One of the biggest benefits of the goal setting in Workday is that it allows our people to align their own individual goals with the bigger GNS Science picture, says Peter.

"Where everyone can see how their work fits into what their team is working towards, and what the organisation is working towards, everyone can come to work knowing how they're contributing to a cleaner, safer, and more prosperous Aotearoa New Zealand".

LAND AND MARINE GEOSCIENCE

UNDERSTANDING TE RIU-A-MĀUI ZEALANDIA

Lower Hutt

15
THE 15 MAPS TELL A 100 MILLION-YEAR-OLD STORY ABOUT THE CONTINENT

150
THE MAPS REPRESENT THE WORK OF COUNTLESS GEOSCIENTISTS OVER THE PAST 150 YEARS

A NEW SUITE OF GEOLOGICAL MAPS PRODUCED BY GNS SCIENCE MARK A SIGNIFICANT STEP FORWARD IN OUR UNDERSTANDING OF TE RIU-A-MĀUI ZEALANDIA.

The 15 maps tell a 100 million-year-old story about the continent – how it took shape, moved, and split away from the Gondwana supercontinent over time.

The better we understand the geological processes that shaped the continent, the better Aotearoa New Zealand can make informed decisions about things like geohazard resilience, sustainable resource management, and climate change adaptation.

Published in September 2022 in the *New Zealand Journal of Geology and Geophysics*, the mapped reconstructions reveal how far we drifted north from polar latitudes in the Cretaceous period, and how parts of southernmost Zealandia have climbed from ~80°S to 50°S over the last 100 million years.

Not only do the maps show how the continent has formed, they also give us a better picture of how big it is today – roughly 4300 km in length and stretched over about 39° of latitude.

GNS Science Sedimentologist, Dominic Strogen, is the lead author on the paper. He explains that these kinds of maps are useful to more than just those who study why continents break apart, deform, and collide. The maps provide a wider geological context for almost all of the research done at GNS Science, and in the wider geoscience community.

"The work is particularly useful to those studying hazards, both faults and volcanoes. Understanding how these systems have evolved through time is important, especially in somewhere with an active plate boundary like Aotearoa New Zealand".

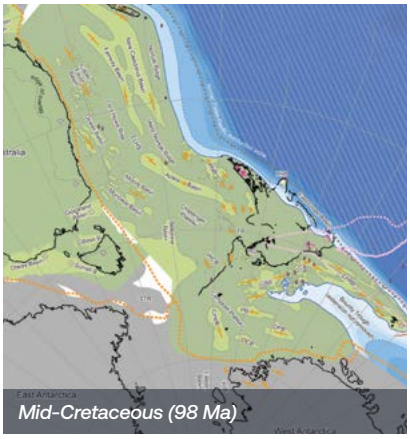
The maps represent the work of countless geoscientists over the past 150 years, both at GNS Science and at research institutes around the world.

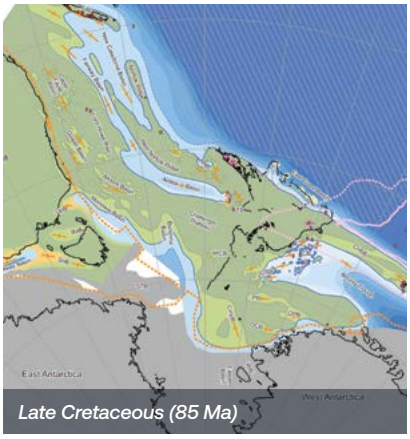
"By putting these new maps out there, we are inviting the scientific community to help us find the holes and improve them over time," says Dominic.

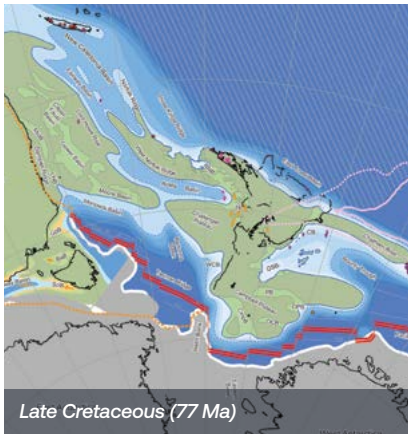
"THESE MAPS OF THE PAST ARE MORE ABOUT THE FUTURE. THE MORE WE DISCOVER, THE MORE WE CAN ADD. THE MORE DATA WE INPUT INTO THESE MODELS, THE MORE INTERESTING THEY BECOME AND THE MORE INSIGHTS THEY REVEAL".

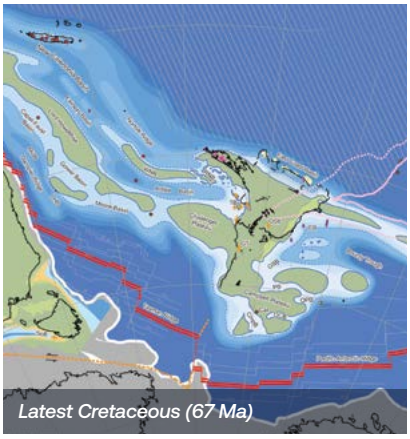
DISCOVER MORE:
nzherald.co.nz/nz/zealandia-the-100-million-year-story-of-the-lost-continent-beneath-nz/LT6M3HCXZBA5JPO4P6MYCYNMPE

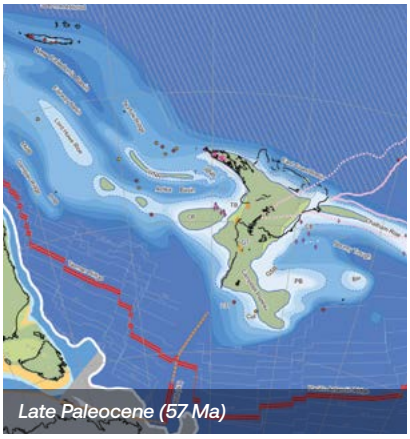
TE RIU-A-MĀUI ZEALANDIA EVOLVING THROUGHOUT THE AGES

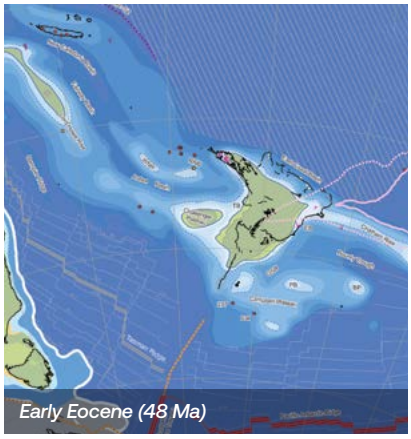

Mid-Cretaceous (98 Ma)

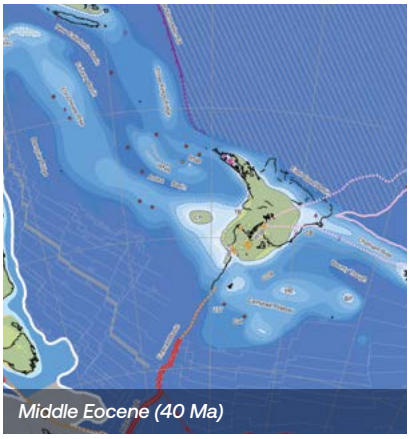

Late Cretaceous (85 Ma)

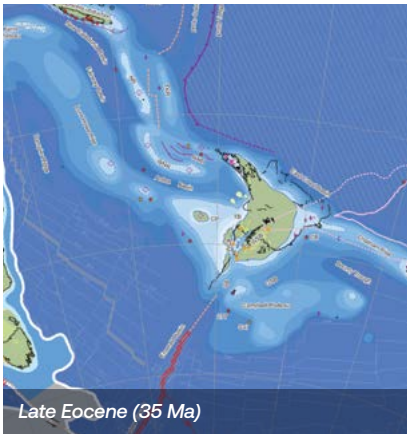

Late Cretaceous (77 Ma)

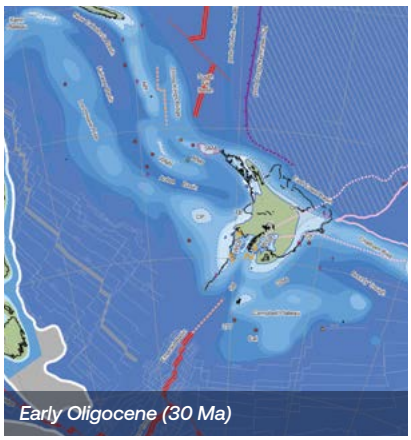

Latest Cretaceous (67 Ma)

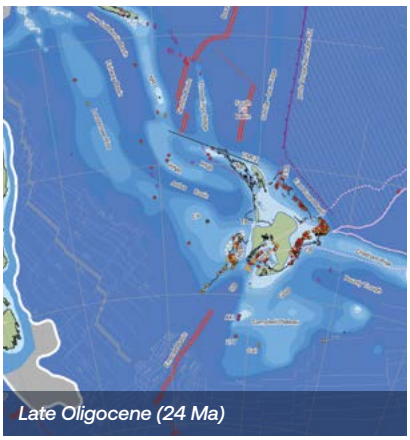

Late Paleocene (57 Ma)

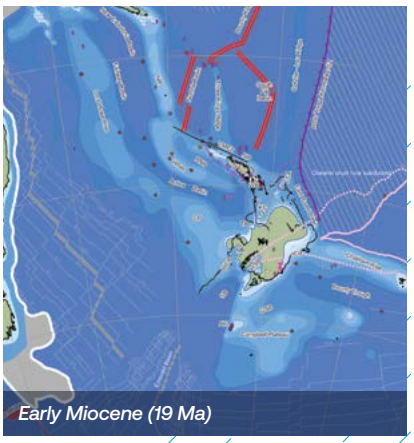

Early Eocene (48 Ma)


Middle Eocene (40 Ma)

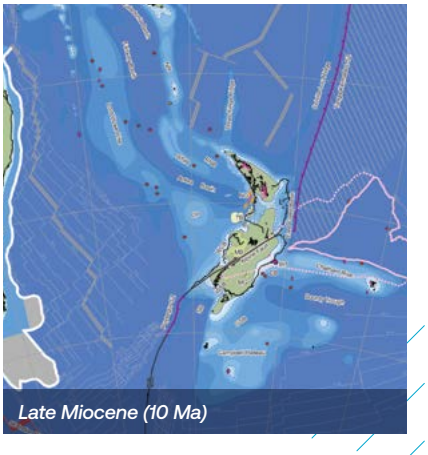

Late Eocene (35 Ma)


Early Oligocene (30 Ma)

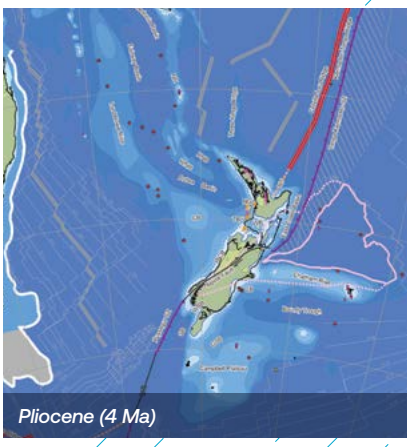

Late Oligocene (24 Ma)


Early Miocene (19 Ma)

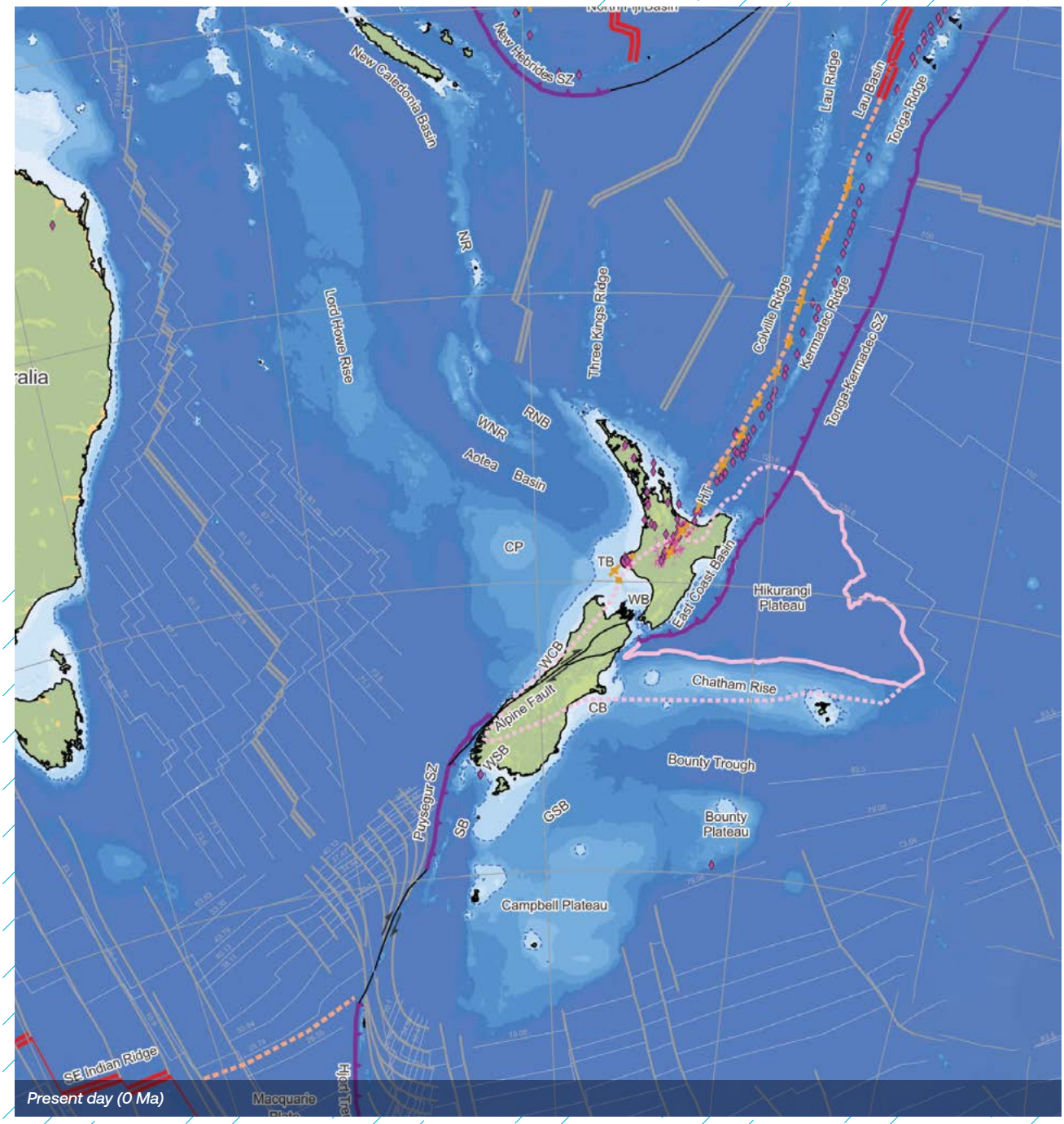
Middle Miocene (14 Ma)



Late Miocene (10 Ma)



Pliocene (4 Ma)



Present day (0 Ma)

LAND AND MARINE GEOSCIENCE

A NEVER-BEFORE-SEEN VIEW OF WHAT LIES BENEATH RUAPEHU MAUNGA


Ruapehu Maunga

RECENT MAGNETOTELLURIC MAPPING WILL PROVIDE A NEVER-BEFORE-SEEN VIEW OF THE MAGMA AND FLUIDS BENEATH MOUNT RUAPEHU – A DISCOVERY ENRICHED BY TIKANGA GENEROUSLY SHARED BY OUR NGĀTI RANGI PARTNERS.

By recording variations in naturally occurring electric and magnetic fields, magnetotelluric (MT) surveys provide a 3D image of the electrical conductivity of rocks deep beneath the Earth's surface.

Rocks that are partially molten, or that contain very high-temperature fluid, are much more conductive than normal rocks. MT datasets essentially paint a picture of magma and geothermal systems in the Earth by showing areas of high and low conductivity.

The better we understand these systems, the better we can interpret volcanic activity during periods of unrest. This supports the best possible science advice for decision makers.

GNS Science's recent mapping at Mount Ruapehu was done in partnership with Ngā Waihua o Paerangi (Ngāti Rangi). The data fills a large gap in pre-existing MT coverage.

The surveying was preceded by pōwhiri, whakawhanaungatanga, and a cultural induction by Ngāti Rangi in Ohakune. On the first morning under clear blue skies, through karanga, karakia, and whakatau, the GNS Science team was welcomed on to Ruapehu, just above the Wāhianoa Stream Valley.

Ngāti Rangi shared a glimpse into the Māori worldview, and how the MT research is of interest to them.

"Kākā te Wharetoka o Paerangi, Kākā hoki ko ahau.

"The eternal flame from the House of Stone of our ancestor Paerangi will continue to burn vibrantly within his descendants.

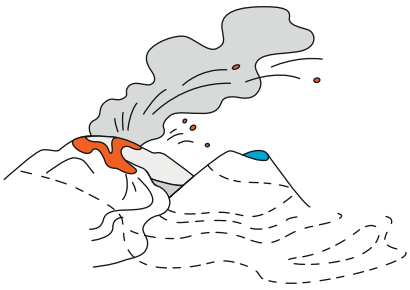
"WE OF NGĀ WAIHUA O PAERANGI (NGĀTI RANGI) VALUE THE PARTNERSHIP FORGED WITH GNS TE PŪ AO AND THE SHARING OF OUR CULTURAL NARRATIVE AND TIKANGA IS A VERY IMPORTANT PART OF THIS RELATIONSHIP."

"The data collected by Te Pū Ao informs us of the magnitude and presence of our tupuna maunga Ruapehu.

"This project has already strengthened our relationship with GNS at our Ngāti Rangi Puanga-Matariki wānanga and Maunga Karakia. We are committed to this working relationship and look forward to other projects".

GNS Science geophysicist, Ted Bertrand, who is leading this MT research, says the partnership with Ngāti Rangi has greatly enriched the project and has been deeply appreciated.

"The partnership with Ngāti Rangi has provided a connection between the research, the land, and the people. These roots will grow through our ongoing relationship as the mahi continues through the scientific process of analysing and modelling the data to interpret and communicate the results and images generated."



ENVIRONMENT AND CLIMATE

MĀTAURANGA CRUCIAL TO UNDERSTANDING CULTURALLY SIGNIFICANT STREAM


Napier


Hawke's Bay

THE TE WHAKAHEKE O TE WAI GROUNDWATER RESEARCH PROJECT HAS BEEN WORKING WITH THE NGĀTI KAHUNGUNU COMMUNITY AT BRIDGE PĀ IN HAWKE'S BAY, TO BETTER UNDERSTAND THE PARITUA STREAM CATCHMENT.

Te Whakaheke o Te Wai is a multi-year programme led by GNS Science. It aims to enable better freshwater management through improved understanding of the origins and flows of water through our aquifers and connected surface water systems.

At a national level, Te Whakaheke o Te Wai is working towards a world-first series of maps showing the source and flow patterns of Aotearoa New Zealand's 200 known aquifers and large river catchments, along with the development of a National Groundwater Age Model. But the project is also having an impact at a regional and local level, with mātauranga Māori playing a vital role.

The Heretaunga Plains and their vast aquifer system is one of the case studies for the project. Within this area is the Paritua Stream, a relatively small stream with big significance to the local community.

"This is a stream that's usually deep enough for the people of that community to swim in, to jump off the bridge into. It's a precious resource for its kai values, for collecting watercress, for its tuna to travel through," says Ocean Mercier, Victoria University of Wellington Associate Professor, and Mātauranga Research Supervisor.

The stream is experiencing increasingly frequent low flow and no flow periods. Mana whenua worked with Te Whakaheke o Te Wai team to share their knowledge of the stream, knowledge that was fed into the scientific modelling seeking to better understand what was occurring.

"THE MĀTAURANGA THAT MANA WHENUA BRING IS CRITICAL. THEY HAVE WHAKATAUKĪ, ORAL HISTORIES, THAT RELATE VERY SPECIFICALLY TO GROUNDWATER SYSTEMS. THEY HAVE THESE IMAGES OF WHAT THE GROUNDWATER SYSTEMS LOOK LIKE, BASED ON THEIR KNOWLEDGE OF WHERE THE SPRINGS HAVE EMERGED AND HOW THE RIVERS ARE FLOWING, HOW THEY ALL CONNECT TOGETHER."

Catherine Moore, programme co-lead and GNS Science Senior Groundwater Modeller, describes how working with mana whenua has enriched the project.

"It's rich knowledge that covers a large area and over a large time frame. And that can be really important information that we're not used to looking at."

To build the groundwater models for the Heretaunga Plains, Moore combines Mātauranga o te Wai, with council data, groundwater isotope data collected by programme co-lead Uwe Morgenstern, and information from geophysics about the structure of the underground aquifer system.

The result is tools that recognise the multiple stresses and spatial and temporal scales involved in the changes experienced by the Paritua Stream, to support robust environmental management decisions around stream restoration.

200

AOTEAROA HAS 200 KNOWN AQUIFERS AND LARGE RIVER CATCHMENTS

ĀTEA A RANGI STAR COMPASS, NAPIER

NATURAL HAZARDS AND RISKS

VOLCANIC UNREST HIGHLIGHTS COMMUNITY RELATIONSHIPS


Lake Taupō

5.7
A MAGNITUDE 5.7 EARTHQUAKE IN 2022 RESULTED IN TWO SMALL TSUNAMI

8
TAUPŌ VOLCANO WAS REDUCED TO VAL0 IN MAY 2023

IN 2022, FOR THE FIRST TIME EVER, GNS SCIENCE RAISED THE VOLCANIC ALERT LEVEL (VAL) AT TAUPŌ VOLCANO FROM VAL0 (NO VOLCANIC UNREST) TO VAL1 (MINOR VOLCANIC UNREST). MONITORING AND KEEPING LOCALS INFORMED DURING THE UNREST PERIOD PROVIDED OPPORTUNITIES TO STRENGTHEN OUR RELATIONSHIPS WITH THE LOCAL COMMUNITY AND IWI.

A significant increase in felt earthquakes served as a regular reminder for locals about the volcanic activity at play beneath the lake. The largest – a M5.7 on 30 November 2022 – was widely felt and resulted in two small tsunami.

Clear communication was essential to keep decision makers informed, and to manage local interest. We produced and shared a series of videos featuring our volcano experts providing updates on activity over the unrest period. These were positively received by both stakeholders and local communities.

We worked closely with our partners at Taupō District Council and Tūwharetoa Māori Trust Board to ensure updates and public safety messages were being heard by the people who needed them.

"It was crucial for us to work closely with the Tūwharetoa Māori Trust Board, the landowner of Lake Taupō," explains GNS Science Volcanology Team Leader, Nico Fournier.

"Regular hui were organised not only to ensure that the Trust Board had the information they needed to make informed decisions, but also that we worked hand in hand towards improving the level of volcano monitoring at Taupō volcano, with the installation of further instruments around the lake."

GNS Science researchers ran a short survey to help understand Rotorua and Taupō district residents' views on different hazards. The survey asked questions about different hazard events, emergency drills, and participant demographics. The findings will help inform future research and emergency management work in the region.

The survey is part of a collaborative five-year project called ECLIPSE – *Eruption or Catastrophe: Learning to Implement Preparedness for future Supervolcano Eruptions* – that is deepening our understanding of volcanic and seismic activity in the area. This work is funded by the Ministry of Business, Innovation and Employment's Endeavour Fund and delivered by a multi-disciplinary team of scientists from Te Herenga Waka Victoria University of Wellington, Massey University, the University of Canterbury and GNS Science, along with iwi, hapū, and emergency management personnel.

Taupō volcano was reduced to VAL0 in May 2023, but the unrest could start up again. GNS Science continues to provide public education on volcanic hazards, and work with local Civil Defence Emergency Management and iwi to ensure they are up to date on any activity.

DISCOVER MORE:
youtu.be/AbXQeA0zSfI

ENERGY FUTURES

CO_2 REINJECTION FOR REDUCTION AND RESILIENCE

AOTEAROA NEW ZEALAND'S ENERGY SECTOR MUST STRIKE A CAREFUL BALANCE IN ORDER TO MEET ITS MOST PRESSING CHALLENGES – UNLOCKING A CARBON-NEUTRAL ECONOMY BY 2050 AND INCREASING ENERGY SECURITY FOR OUR COMMUNITIES.

GNS Science experts are working to navigate the tightrope between these two critical aims and seek practical ways forward using geothermal resources.

Geothermal power generation will be a vital building block in a more resilient energy system. But to maximise its positive impact, we must find ways to minimise CO_2 emissions from geothermal production and ensure the resilience of the natural environment and supporting power infrastructure.

By getting to the core of the complex processes inside New Zealand's geothermal fields, GNS Science's Experimental Geochemistry Laboratory (EGL) is playing a pivotal role in addressing these challenges. The team is unravelling the complexities of carbon-neutral geothermal power by simulating the extreme pressure, temperature, chemical and depth conditions of geothermal reservoirs in the lab and undertaking computer modelling.

Bruce Mountain, EGL's Lead Scientist, says recent work has focused on geothermal brine reinjection – the process by which all extracted water is returned to the geothermal reservoir. Specifically, the EGL team has been looking at how reintroducing CO_2 released from the power generation process might affect the impact of brine reinjection.

"Reintroducing CO_2 during brine reinjection has the potential to address two key challenges for the geothermal industry, reducing greenhouse gas emissions and maintaining 'injectivity' – the fluid flow, pressure, and permeability of the reservoir required to sustain the energy efficiency of the power station."

"CO_2 reinjection has the potential to influence processes like silica scaling and the overall acidity of the brine fluids."

Early results show that reinjecting CO_2 concentrations equal to the level released by power production minimises silica scaling and maintains the injectivity of the resource. Investing in CO_2 reinjection could therefore increase the longevity of generators.

The EGL team is also focused on how CO_2 reinjection methods may be best applied to geothermal systems from Japan, Indonesia, and Philippines – supporting our international community to drive toward a carbon-neutral future.

ENERGY FUTURES

UNLOCKING INNOVATION THROUGH TE REO MĀORI


Champagne Pool, Waiotapu

TE REO MĀORI EXPERTS AND GEOTHERMAL SCIENTISTS COLLABORATED TO CREATE SHARED LANGUAGE TOOLS THAT BRING TOGETHER MĀTAURANGA MĀORI AND WESTERN SCIENCE.

Until recently there was a lack of relevant te reo Māori words for key scientific terms used in geothermal research – a challenge that The Waiwhatu Project set out to address as part of the Geothermal: The Next Generation Endeavour Fund programme.

One example of many, Ngawha means hot spring but is commonly used to replace the word geothermal, which doesn't communicate the full breadth of what geothermal encompasses. Through the active exchange of ideas and knowledge, scientists have considered technical concepts relevant to Earth sciences, geothermal, and volcanology, and shared them with a team of te reo Māori experts to interpret through a te ao Māori lens.

"This is a great example of how the use and development of te reo Māori terms helps to unlock the innovation potential of Māori knowledge, resources and people – the core goal of Vision Mātauranga" says Mereana Wilson-Rooy, GNS Science's Manager, Māori Strategy and Partnerships.

Through the combined mahi of Uenuku Fairhall, Andy Blair, Paul Siratovich, Corey Ruha and Aroha Campbell the project has created six new kupu (words) for geothermal terms: *tokarewa (magma), rangitoto (lava), waiwhatu (geothermal fluid), māpuna (reservoir), ngaohū (enthalpy), kūwhewhewhewhe (wrinkling).*

For te reo speakers, the kupu are instantly meaningful. The new word for geothermal *waiwhatu* combines the existing words *wai* (liquid, oil etc) and *whatu* (stone, core) to describe fluid from the core (or the heart of the Earth) woven through the inside of the Earth to the surface.

With the kupu developed, the next stage in the project is underway – sharing the words with Māori and geothermal communities, te reo Māori speakers, and the wider science research audience.

GNS Science showcased the words through a social media 'kupu o te rā' (word of the day) video campaign during Geothermal Week 2023. The Waiwhatu Project team intend to work with Te Taura Whiri i te Reo Māori Māori Language Commission to have the words included in the next version of the Māori dictionary, and will be holding a hui with the geothermal community to encourage uptake of the kupu.

6
NEW KUPU FOR GEOTHERMAL TERMS

TOKAREWA: MAGMA

RANGITOTO: LAVA

WAIWHATU: GEOTHERMAL FLUID

MĀPUNA: RESERVOIR

NGAOHŪ: ENTHALPY

KŪWHEWHEWHEWHE: WRINKLING

DISCOVER MORE:
geothermalnextgeneration.com/updates/waiwhatu-project-developing-shared-language

ENERGY FUTURES

SECURING THE FUTURE OF GEOTHERMAL ENERGY

GNS SCIENCE EXPERTISE IS POWERING OUR INDUSTRY PARTNERS TOWARDS A GREENER FUTURE, IN PURSUIT OF A CARBON-ZERO AND RESILIENT ENERGY SYSTEM.

New consents secured by Contact Energy in the Wairakei Geothermal Field are a testament to our shared expertise in, and commitment to, unlocking the potential of geothermal for a sustainable future.

The new consents will bolster the geothermal power production capability of Wairakei Geothermal Field and ultimately deliver a more resilient base-line electrical power system. Not only do they propel our shared ambitions for a carbon-neutral future, the consents also herald an era of heightened geothermal generation and innovation.

The Wairakei Geothermal Field, which already boasts 320 MW capacity, is set to surge to 400 MW – enough to power about 70,000 more homes. This is made possible by meticulous planning, a minimal increase in geothermal take, and a conscientious effort to reduce environmental impact.

GNS Science has played a critical role in shaping Contact Energy's vision for sustainable geothermal power production at the site over the next 35 years. Our experts were integral to the reconsenting process as core members of a collaborative team providing critical technical counsel.

Leveraging decades of proficiency in geothermal, groundwater, subsidence, and surface geothermal features, our experts adeptly guided resource assessments and assessment of effects reports in the reconsenting process. Our multidisciplinary approach, bolstered by the expertise of geologists, geophysicists, geochemists, and technical specialists, ensured a comprehensive understanding of the intricacies at play in geothermal systems.

"OUR JOURNEY WITH CONTACT ENERGY HAS BEEN ONE OF SHARED DEDICATION, GROWING EXPERTISE AND TRUST. AS THE WAIRAKEI GEOTHERMAL FIELD EMBARKS ON THIS TRANSFORMATIVE GROWTH, OUR EXPERTS WILL CONTINUE TO BE CORNERSTONE, PROVIDING THE KNOWLEDGE AND GUIDANCE NEEDED TO NAVIGATE THE COMPLEXITIES OF RESPONSIBLE GEOTHERMAL DEVELOPMENT," SAYS GNS SCIENCE GEOPHYSICIST, ROBERT REEVES.

"Looking ahead, we are excited about pioneering sustainable solutions and furthering the frontiers of geothermal energy technology. With each accomplishment, we move closer to a future where our communities benefit from cleaner, more resilient renewable energy."

400
THE WAIRAKEI GEOTHERMAL FIELD ENERGY CAPACITY IS INCREASING FROM 320 MW TO 400 MW

70,000
THE WAIRAKEI GEOTHERMAL FIELD ENERGY INCREASE IS ENOUGH TO POWER 70,000 MORE HOMES

DISCOVER MORE:
contact.co.nz/aboutus/our-story/our-projects/geofuture

NESTLED IN TAUPŌ, THE WAIRAKEI GEOTHERMAL FIELD GENERATES POWER FOR HOMES ACROSS AOTEAROA

LAND AND MARINE GEOSCIENCE

CYCLONE GABRIELLE UNCOVERS NEW SECRETS


Mangahouanga Valley


Mangahouanga Valley

CYCLONE GABRIELLE TRANSFORMED GENTLE STREAMS AND RIVERS IN MAUNGATANIWHA NATIVE FOREST TO ROARING TORRENTS AS THE STORM TORE THROUGH HAWKE'S BAY.

The pressure of millions of cubic metres of rainwater scoured the riverbeds and overturned rocks the size of shopping-trolleys.

In the wake of its devastation, precious geological taonga were revealed – an untold number of previously undiscovered fossils that might otherwise have remained hidden for eternity.

Forest Lifeforce Restoration Trust reached out to GNS Science after making this exciting discovery while assessing the cyclone's devastation in Northern Hawke's Bay.

Referring to photos of the discovery, GNS Science's National Paleontological Collection Manager, Marianna Terezow, tentatively identified the fossils as huge vertebrae from an elasmosaurus and a mosasaur.

Elasmosaurus and mosasaur were enormous marine dinosaur-like reptiles that lived over 80 million years ago. Elasmosaurus are recorded to have reached up to 14 metres in length. While mosasaur fossils have been discovered before in Aotearoa New Zealand, they are not particularly common.

"While the Mangahouanga Valley in Maungataniwha is renowned for being rich with fossils of marine reptiles and dinosaurs, the scale of this discovery could be unprecedented," says Marianna.

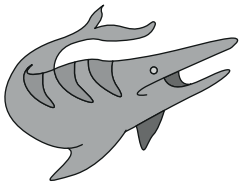
Over the last decade, GNS Science's Paleontology Team has worked closely with Forest Lifeforce Restoration Trust to identify and record their fossil finds. This long-standing relationship has contributed significant scientific knowledge to New Zealand's fossil record and to the National Paleontological Collection. Where there is no requirement for physical analysis, the taonga remain on the whenua where they were found.

"THE APTLY NAMED MAUNGATANIWHA SANDSTONE, WHICH IS THE MAIN ROCK UNIT IN THE AREA, STILL HAS MANY INTERESTING STORIES TO TELL. IT'S GREAT TO HAVE THE KNOWLEDGEABLE AND SKILLED PEOPLE AT THE TRUST MAKING THESE DISCOVERIES," SAYS MARIANNA.

"Judging by what we found in just one morning, Cyclone Gabrielle will contribute hugely to our collective knowledge about the creatures that called this place home in the depths of pre-history," said Pete Shaw, the Trust's Forest Manager.

80

ELASMOSAURUS AND MOSASAUR LIVED OVER 80 MILLION YEARS AGO



DISCOVER MORE:

gns.cri.nz/data-and-resources/new-zealand-national-paleontological-collection-and-associated-databases

gns.cri.nz/news/gabrielle-uncovers-new-secrets-set-in-stone

MEDIA COVERAGE:

International and National – Radio New Zealand (+ Greymouth Star), Stuff (MSN UK + LiveScience) Otago Daily Times, 1News Online, Yonhap News Korean

Local – Hawke's Bay Today (NZ Herald) (+ Wairoa Star)

NATURAL HAZARDS AND RISKS

MAPPING 140,000 LANDSLIDES FOLLOWING CYCLONE GABRIELLE


Hawke's Bay

POTENTIALLY THE LARGEST LANDSLIDE-TRIGGERING EVENT ON RECORD IN AOTEAROA, CYCLONE GABRIELLE CAUSED THOUSANDS OF LANDSLIDES ACROSS THE NORTH ISLAND. LANDSLIDES DAMAGED HOUSES AND INFRASTRUCTURE, AND WERE DIRECTLY RESPONSIBLE FOR THE DEATHS OF FIVE PEOPLE.

To support the emergency response and recovery of this extreme weather event, GNS Science was called upon to identify and map Cyclone Gabrielle landslides, inform stakeholders where they occurred, and forecast where more could occur in a future event.

As Cyclone Gabrielle was approaching, the GNS Science landslides team used NIWA rain forecasts, geology data and population and infrastructure maps to identify where landslides would most likely cause the greatest risk to life and lifeline infrastructure.

This critical information was shared with emergency responders to support them to prepare for and respond to the life threatening and disruptive effects of landslides.

National Emergency Management Agency Chief Science Advisor, Thomas Wilson said GNS Science's approach to supporting the disaster response and ongoing recovery efforts has been exemplary.

"THE GNS LANDSLIDE TEAM'S SWIFT RESPONSE AND PROFESSIONAL COMMITMENT TO DELIVERING TRUSTED AND USEFUL SCIENCE ADVICE HAS BEEN ESSENTIAL FOR RESPONSE AND RECOVERY OPERATIONS," PROF WILSON SAID.

"They mobilised quickly to provide urgent science advice to support life-safety decisions during the response and were well known and trusted by regional and local partners – this was essential. The regional landslide mapping, with their university and other CRI partners, is very valuable for recovery decision-making and improving our resilience to future landslide-inducing events."

In Gabrielle's aftermath, GNS Science sent five teams to undertake aerial reconnaissance of where landslides and damage had occurred in the most heavily impacted regions. The teams also swept for hidden hazards that may trigger without warning, including landslide dams and failing slopes threatening urban property and roads.

Images, intelligence, and forecasts were shared with stakeholders daily using a custom mobile app to enable them to prevent further damage and loss of life from potential landslide hazards.

The rainfall-induced landslide tool developed by GNS Science was initially co-developed by the SSIF Landslide Hazards and GeoNet project, with some additional funding from the Resilience to Nature's Challenges National Science Challenge project to apply it to an Auckland case study. The tool is an input to landslide runout modelling that forecasts potential impacts of future rainfall events.

The team has identified at least 140,000 landslides caused by Cyclone Gabrielle. Creating a spatially accurate landslide inventory of this immense event, that can be simultaneously disseminated to emergency responders, is an ongoing task.

A multi-agency team from GNS Science, Manaaki Whenua, and the universities of Canterbury and Auckland is hard at work completing the job.

GNS Science Engineering Geologist, Chris Massey, said the inventory is one of the world's largest landslide datasets directly related to a single storm event.

"This new dataset enables us to link landslide occurrence to the rain that triggered them, allowing us to hindcast the magnitude of the impacts. Our landslide impact models are being retrained on this new dataset, which will be used to forecast the potential impacts more accurately from future landslide-triggering events," Dr Massey said.

The Cyclone Gabrielle landslide recovery project is funded $1.45 million by MBIE under the Extreme Weather Research Platform (EWRP), and the GeoNet programme.

DISCOVER MORE:
youtu.be/9zmAGiTIEU4

gns.cri.nz/news/new-news-page-8

NATURAL HAZARDS AND RISKS

INSPIRING SCIENCE IN OUR GEOTHERMAL WONDERLAND

ROTORUA BECAME THE WORLD'S EPICENTRE OF VOLCANOLOGY IN JANUARY, WHEN IT HOSTED THE INTERNATIONAL ASSOCIATION OF VOLCANOLOGY AND CHEMISTRY OF THE EARTH'S INTERIOR (IAVCEI) SCIENTIFIC ASSEMBLY.

Around 900 scientists from 41 countries gathered to share the latest volcano and Earth science research. More than 100 others joined online. GNS Science, together with our hosts University of Waikato, and Principal Sponsor, Toka Tū Ake EQC, took the opportunity to involve the community – hosting a festival of demonstrations and 'meet the expert' events in a well-attended public open day.

"The diverse context of the New Zealand volcanic environment puts us at the forefront of volcano research," GNS Science co-convenor, Graham Leonard, said.

"OUR SCIENCE IS HELD IN VERY HIGH REGARD INTERNATIONALLY, AND THIS IS SHOWN BY THE HUGE NUMBER OF SPECIALISTS TRAVELLING HERE TO LISTEN AND LEARN ABOUT OUR RESEARCH AND SHARE THEIR INSIGHTS."

Against the backdrop of the Rotorua caldera and nestled amongst some of Aotearoa New Zealand's most iconic volcanic landforms and deposits, IAVCEI 2023 covered every aspect of volcanology – as diverse as magma dynamics, statistical eruption forecasting, exploring renewable energy potential, probabilistic estimation of volcanic hazard and risk, as well as Māori history and legend, and the impressions and impacts volcanoes make on society.

Mid-conference field trips highlighted the volcanic and geothermal geology of the central Taupō Volcanic Zone, explored geothermal development in an active volcanic system and discussed social and indigenous impacts of volcanic eruptions.

The conference focused on collaboration and engagement, and under the able directorship of University of Canterbury's Ben Kennedy, that extended to the general public. A 'Volcanofest' day attracted hundreds of people to enjoy a 'hands-on' experience, with the opportunity to explore volcano models, meet and chat to experts, and learn about volcanoes and seismic activity in Aotearoa New Zealand and around the world.

Co-convenor and Senior Lecturer in Earth Sciences at University of Waikato, Dr Adrian Pittari, said it was an interactive way for the community to learn more about the science that they see and live with every day.

"Aotearoa New Zealand is part of the Pacific Ring of Fire, and our communities need to be aware of volcanology and be prepared for volcanic hazards. VolcanoFest provided a really safe and engaging opportunity for communities to learn and interact with both the science and the scientists."

900
SCIENTISTS GATHERED FOR THE CONFERENCE

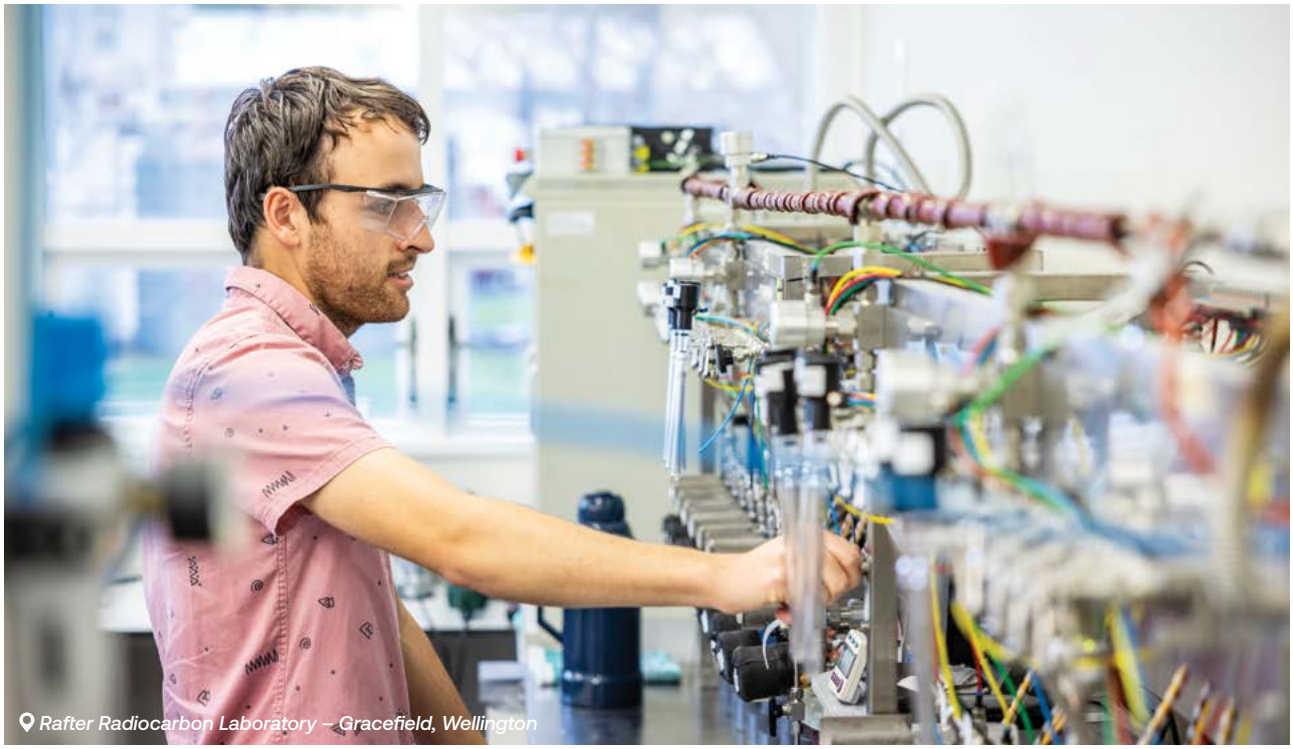
41
SCIENTISTS CAME FROM 41 DIFFERENT COUNTRIES

100
MORE THAN 100 OTHERS JOINED ONLINE

Mt Ngāuruhoe

ENVIRONMENT AND CLIMATE

MODELLING AUCKLAND'S CARBON BALANCE



Rafter Radiocarbon Laboratory – Gracefield, Wellington

GNS SCIENCE'S CARBONWATCH NZ TEAM IS USING 'BOTTOM-UP' MODELLING AND 'TOP-DOWN' ATMOSPHERIC MEASUREMENTS TO BUILD A COMPREHENSIVE PICTURE OF AUCKLAND'S CARBON EMISSIONS AND SINKS TO BETTER INFORM CARBON MITIGATION STRATEGIES.

For greenhouse gas mitigation policies to be effective, decision makers need confidence that the promised emissions offsets are effectively reducing the amount of carbon in the atmosphere.

Emissions are traditionally reported through 'bottom-up' modelling, relying on economic information at a national level e.g. the amount of petrol imported into the country annually. This information can tell us if we're meeting our international contributions but is of limited use for local policy makers.

GNS Science Data Scientist and Modeller, Liz Keller, Radiocarbon Science Team Leader, Jocelyn Turnbull and Carbon Cycle Scientist, Tim Hilton have led the development of a breakthrough data product for the Auckland Region that can provide CO_2 emissions information at a 500m and 1-hr time scale.

They're also working on a second model of carbon sinks and the land-carbon exchange, to determine the transfer of carbon between the soil and the atmosphere. A carbon sink is anything that absorbs more carbon from the atmosphere than it releases – for example, plants, the ocean, and soil.

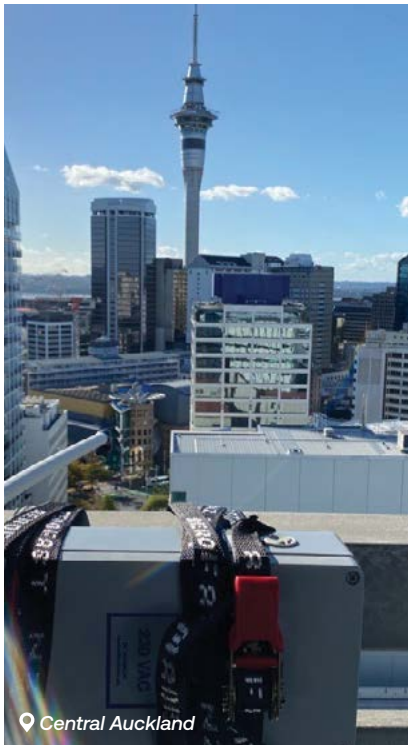
"How we manage our city parks, our front gardens and roadside verges, can all make a really big difference to a city's carbon balance. This research will help us understand how those green space management decisions result in an uptake or a release," Turnbull says.

The team has carried out measurements and analyses to verify and improve the models using the actual atmospheric distribution of CO_2 across the city, accounting for wind and other weather factors.

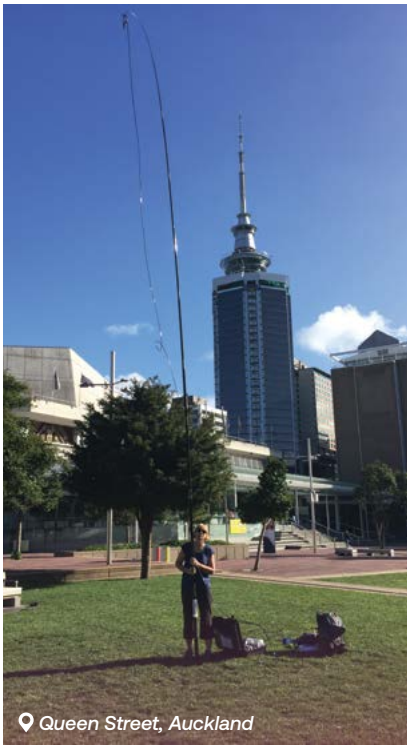
Four atmospheric monitoring stations provide continuous monitoring of CO_2, meteorological information, and radiocarbon measurements that help the team to understand how much of the CO_2 is coming from fossil fuel combustion and how much is coming from natural processes.

4
ATMOSPHERIC MONITORING STATIONS PROVIDE THE CONTINUOUS MONITORING OF CO_2

500
A BREAKTHROUGH DATA PRODUCT CAN PROVIDE CO_2 EMISSIONS INFORMATION AT A 500M AND 1-HR TIME SCALE


Central Auckland


Ōrākei


Queen Street, Auckland

Together, the models and measurements create a valuable tool for urban planning. The team will apply the approach taken in Auckland to our other urban centres once further funding is secured.

"WITH THIS DETAILED, VALIDATED EMISSIONS INFORMATION IN HAND, AOTEAROA CAN MAKE INFORMED URBAN PLANNING AND DEVELOPMENT DECISIONS TO MITIGATE EMISSIONS NOW, AND IN THE FUTURE." JOCELYN TURNBULL, GNS SCIENCE RADIOCARBON SCIENCE LEADER

GNS Science's Rafter Radiocarbon Laboratory is crucial to this work, providing high precision measurements of radiocarbon in CO_2. It's the oldest continuously operating radiocarbon facility in the world, with a long history in climate science – it was the first lab in the world to measure radiocarbon in atmospheric CO_2 in 1954.

It's the only laboratory in Aotearoa New Zealand that can do these high precision measurements, and there are only a few others worldwide that can do so, so it has a vital role to play in understanding our carbon balance.

CarbonWatch NZ is an MBIE Endeavour Fund programme. It is led by NIWA and addresses crucial carbon cycle questions in Aotearoa New Zealand's farmland and urban environments, and indigenous and exotic forests. GNS Science is leading the urban component and is also playing a significant role in the farmland research.

1954
GNS SCIENCE'S RAFTER RADIOCARBON LABORATORY HAS BEEN CONTINUOUSLY OPERATING SINCE 1954

DISCOVER MORE:
rmets.onlinelibrary.wiley.com/doi/10.1002/gdj3.181

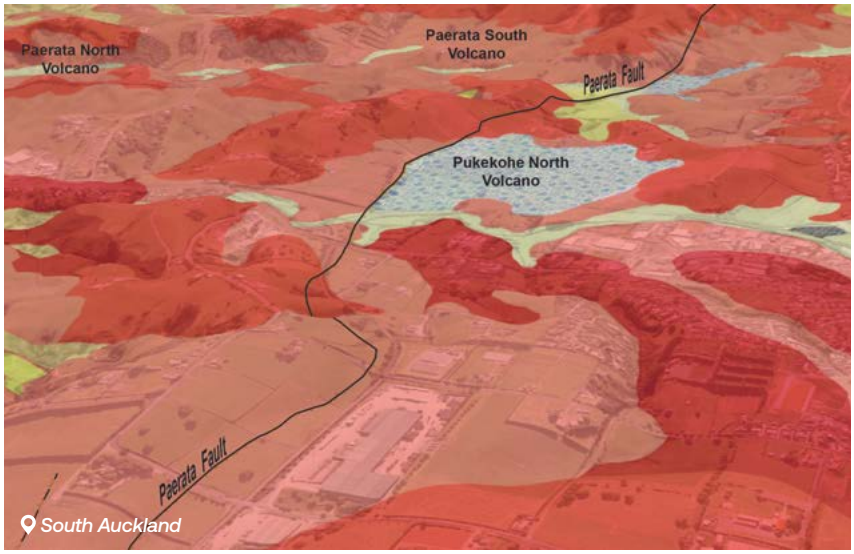
gns.cri.nz/research-projects/carbonwatchnz

Queen Street, Auckland

CITY PARKS, FRONT GARDENS AND ROADSIDE VERGES ALL ACROSS AUCKLAND CAN MAKE A BIG DIFFERENCE TO CARBON BALANCE

LAND AND MARINE GEOSCIENCE

NEW GEOLOGICAL MAP FOR SOUTH AUCKLAND



30
THIS IS THE FIRST DETAILED GEOLOGICAL MAP OF SOUTH AUCKLAND IN NEARLY 30 YEARS

THE LATEST MAP RELEASED BY GNS SCIENCE'S URBAN GEOLOGICAL MAPPING PROGRAMME PROVIDES CRITICAL NEW INSIGHTS FOR SOUTH AUCKLAND.

The new 1:50,000 geological map covers 830 km^2 between the southern shoreline of Manukau Harbour and the lower Waikato River, revealing accurate locations and definitions of faults and landslides in the area. These insights will support community decision makers and local government in planning, geological hazard and risk assessment, and environmental management.

Among the features identified on the map are three 'new' active fault lines in the area – the Pukekohe (Waiuku) Fault, the Paerata Fault, and the Aka Aka Fault.

"ALTHOUGH FAULTS IN THIS AREA ARE NOT NEW, THIS IS THE FIRST TIME THEY'VE BEEN MAPPED AT THE MODERN LAND SURFACE AND IN SUCH DETAIL," SAYS GNS SCIENCE SENIOR GEOLOGIST, KYLE BLAND.

Improved understanding of the faults' location and activity has allowed them to be specifically incorporated into the recently released revision of the New Zealand National Seismic Hazard Model. This is the first time faults in this area have been included in a national-scale model, deepening our understanding of seismic hazard in this significantly growing region.

The mapping also better defines past landslides in the area, depicting around 800 areas of past (mainly prehistoric) landslide movement. Critically, this data increases our understanding of factors that contribute to landslides in these areas. Cyclone Gabrielle and its impacts on the region emphasised the vital need for this information to be used and acted upon for resilience and planning in these communities.

Being the first detailed geological mapping of South Auckland in nearly 30 years, the map's release was well-received by the local community, data end-users, and our partners at Auckland Council and Waikato District Council.

The new information will be incorporated into the New Zealand Landslide Database hosted by Auckland Council and GNS Science's landslide databases.

830
THE NEW MAP COVERS 830KM^2

800
THE MAPPING DEPICTS AROUND 800 AREAS OF PAST LANDSLIDE MOVEMENT

DISCOVER MORE:

stuff.co.nz/national/131932162/laser-technology-confirms-three-active-fault-lines-near-pukekohe

National Print

newshub.co.nz/home/new-zealand/2023/05/gns-scientists-discover-three-active-fault-lines-under-auckland-dozen-more-possibly-active.html

nzherald.co.nz/nz/new-3d-maps-reveal-hundreds-of-ancient-landslides-south-of-auckland/X2BPNZKIGJBQBLZJTPINEFRRVY/

newshub.co.nz/home/new-zealand/2023/06/gns-scientist-says-it-s-becoming-more-common-to-discover-new-fault-lines.html

TŪHURA PAPATŪĀNUKU GEO NOHO GROWS KNOWLEDGE AND CONNECTION IN TE HIKU NORTHLAND

THIS YEAR TŪHURA PAPATŪĀNUKU GEO NOHO DELIVERED HANDS-ON LEARNING TO OVER 80 MĀORI STUDENTS IN TWO FOUR-DAY WĀNANGA.

The marae-based wānanga are designed to provide taitamariki in remote areas of Northland more equitable access to skilled scientists, science resources, and mātanga Māori (Māori experts).

Focusing on the taiao (the environment) and pūtaiao (science), *Tūhura Papatūānuku* aims to inspire taitamariki to explore the environment and consider a future in the field of science prior to starting high school.

Co-led by GNS scientists, Joe Prebble and Kyle Bland, the design of the wānanga matured through the growing relationships and knowledge exchange with the community. Over the years, the mahi behind *Geo Noho* has built significant community support.

Now *Geo Noho* is co-designed and co-delivered with our partners Far North REAP, Te Aho Tū Roa Programme, and Te Rarawa iwi. Kyle Bland says, "I take a lot of heart from the strong relationships we have in the Far North. I think of our different contributions as like a net, the concept of a kupenga. The more threads that you weave together within your net, the stronger your net becomes."

Tūhura Papatūānuku Geo Noho has been supported through the collective co-funding of GNS Science, Te Aho Tū Roa, Far North REAP and the Biological Heritage National Science Challenge hosted by Manaaki Whenua. These partnerships, and funding from a Ministry of Education Regional Development grant, have enabled new mātauranga Māori taiao lesson plans, resources, waiata, and karakia to be developed for the region.

The two wānanga delivered this year were made possible through support of MBIE's Unlocking Curious Minds fund and the Biological Heritage National Science Challenge.

Not only have the resources behind *Geo Noho* grown, but so has the GNS team supporting it. GNS Scientist Te Aomania Te Koha joined the two wānanga this year and says the experience was deeply valuable to her as a Māori kaipūtaiao (scientist).

"Tūhura Papatūānuku brings together my love of science and the inner need I feel to serve Māori communities. The most recent noho was predominantly delivered in te reo Māori and I found it incredible to be able to kōrero Māori while also standing as a kaipūtaiao for the tamariki."

Ninety Mile Beach

Joe Prebble reflects on the *Geo Noho* wānanga. "We do this because we believe that face-to-face connection is what's needed to bring this knowledge alive for the next generation."

80+
MĀORI STUDENTS GATHERED

2
TWO 4-DAY WĀNANGA WERE HELD FOR STUDENTS IN MAY AND AUGUST

FUTURE SCIENTISTS EXPLORING
NINETY MILE BEACH, NORTHLAND


VODAFONE

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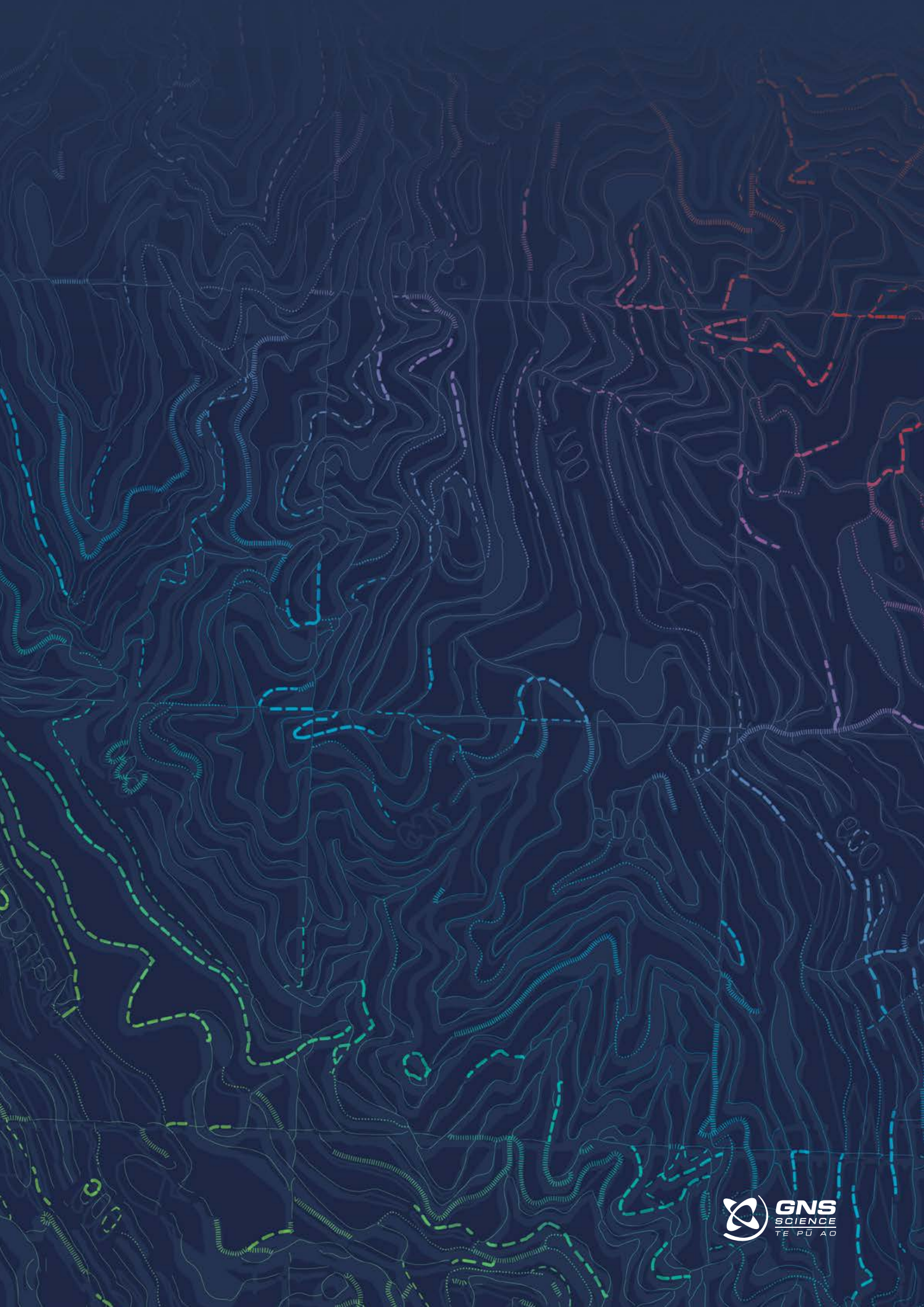
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