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Evaluating rupture characteristics of the potential tsunamigenic earthquakes in the Southwest Pacific using regional array seismology

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Rapid characterization of earthquake rupture is critical for improving tsunami early warning capabilities, particularly for sparsely instrumented regions like the Southwest Pacific. This study explores how array seismology can be utilized for such real-time applications by identifying key parameter settings that control rupture imaging performance. Because observations of large tsunamigenic events in the region are limited, we used a physics-based catalog of synthetic earthquakes (Mw > 8.5) for the Kermadec subduction zone, which incorporates realistic rupture heterogeneity and slip distributions. From this catalog, we selected a diverse subset of events spanning a range of large magnitudes (M8.5-9.1), rupture lengths, and directivity patterns (unilateral and bilateral). Each event was represented as multiple point-source centroid moment tensors, from which synthetic waveforms were computed for the New Zealand seismic network using the open source SPECFEM3D GLOBE software. The simulations were analyzed with Multiple Signal Classification (MUSIC) back-projection to image seismic energy release.

Results show that earthquake magnitude is the primary factor controlling the optimal analysis frequency, while rupture location, length, and directivity influence secondary imaging parametrization. Back-projected seismic radiators align closely with regions of high slip in the input models. This rupture area can be effectively summarized by an elliptical contour, which represents the portion of the fault most responsible for tsunami generation. Compared to the magnitude-to-rupture scaling relations, the elliptical representation provides a more compact and physically meaningful characterization of the tsunami-relevant rupture.

Probing the deep roots of the Auckland Volcanic Field

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While clear frameworks exist for volcanic chains in many settings, distributed intraplate vent fields remain a global enigma. The Holocene Auckland Volcanic Field (AVF) exemplifies the lack of clear frameworks. The AVF shows evidence for relatively deep mantle melting, but does not show obvious contributions from subduction-related sources and is not obviously connected to a lower mantle plume. Some geochemical evidence hints at contributions from volatiles within the transition zone, while shallower small-scale convection or deeper cryptic upwelling cannot be ruled out. To solve the riddle of AVF volcanism, a major multinational seismic imaging project has begun with coordinated geodynamic and geochemical efforts. The U.S. component, emphasized here, includes an enhanced broadband array currently deployed in the Northland Peninsula and a 20-instrument ocean bottom seismometer (OBS) deployment currently planned for 2026. It complements New Zealand and Chinese efforts currently underway, with several foci. First, teleseismic Sp mode conversions beneath the region show a clear lithosphere-asthenosphere boundary conversion, generally 70-80 km deep for the Australian plate. Large conversion amplitudes around the Northland peninsula are consistent with partial melt ponded at the base of the lithosphere, while lower amplitudes directly beneath the AVF may indicate some melt infiltration into the lithosphere. Integrated teleseismic travel-time and attenuation tomography is designed to illuminate the upper mantle and transition zone. Resolution tests indicate that these data should be able to distinguish between upper-mantle-sourced vs. lower-mantle-sourced upwellings. The integration of attenuation signals should allow thermal structure to be distinguished from compositional variations in the lithosphere and asthenosphere. Both will be complemented by regional surface-wave signals once the OBS deployment completes. These results will be tested against geochemical constraints on the depths and volatile contents of melting, and geodynamic models of upper-mantle flow, to resolve the causes of AVF volcanism.

Earth Sciences Processing Laboratory at The University of Auckland

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The Earth Sciences Processing Laboratory provides sample preparation capabilities primarily for the School of Environment, The University of Auckland, with workflows and techniques that are readily applicable to disciplines such as Physics, Chemistry, Marine Science, Engineering, and the Arts. Prepared specimens are utilized across a broad spectrum of analytical applications — ranging from qualitative assessments to high-precision quantitative — with a primary emphasis on petrological investigations.

The facility provides a wide range of preparation methods — such as precision cutting, grinding, polishing, pulverizing, and coring among others.

Environmental Chemistry Laboratory at The University of Auckland

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The School of Environment, Laboratories and Workshops is a key facility within the Faculty of Science at The University of Auckland, offering a wide range of analytical services and expertise across various disciplines and techniques. This center leverages its analytical proficiency to assist researchers in characterizing the composition of matter both qualitatively and quantitatively. It supports studies across all components of our planet, including air, water, earth, biomass, and ecosystems.

The School features over 15 specialized laboratories and workshops. Among them is the Environmental Chemistry Laboratory (EnvChem), which focuses on advancing analytical chemistry methods. This includes refining existing methods, extending them to new types of samples, and developing novel techniques to measure chemical phenomena.

H_2–brine–rock interactions: laboratory insights for geostorage at Ahuroa

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New Zealand is exploring the potential for H_2 geostorage into depleted hydrocarbon reservoirs within Taranaki Basin. Understanding H_2-water-rock interactions are essential but meant to be deeply studied at laboratory.

We developed a laboratory protocol to explore representative H_2 +brine-rock interactions using 1" diameter and ~ 2" long sandstone cores from a borehole in a depleted petroleum field in New Zealand (Ahuroa field). The dominant mineralogy is quartz and feldspar, but other minerals such as calcite and clay are also present. Brine-rock equilibration is performed to ensure no further reaction between the cores and the brine occurs when H_2 is injected. H_2-brine reaction experiments are performed at 1.5 MPa H_2 pressures and the vessel is set at 65◦C for two months. Samples are partially saturated (~30%) to allow efficient H_2-rock interaction. The petrophysical, geomechanical, and geochemical properties are monitored before and after brine/H_2 aging.

Results show that there is a significant reduction in elastic (P- and S-wave) velocity by 25% under zero confinement and 10% subjected to confinement (axial-40 MPa and lateral-10 MPa), respectively. Porosity increases by 2-5%, while permeability increases more significantly (18-35%), confirming the decrease in elastic rock properties. The mechanical properties, static Young's Modulus (YM) are reduced by ~15%, while the dynamic YM decreases by 15-40%. The observations can be explained by the further dissolution of the silicate minerals (e.g., feldspar and clay) after exposure to H_2, as the decrease of pH of the water caused by H+. The microstructure and mineralogical changes are currently being analysed. Future work incorporates geochemical modelling of the H_2 +brine-rock reactive kinetics, and more data set on core samples from other wells in the Taranaki region.

Geometric deep learning for nowcasting and automated characterization of slow slip at the Hikurangi Subduction Zone

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Slow Slip Events (SSEs) are a critical component of the seismic cycle, modulating stress along subduction zones and influencing the timing of large earthquakes. The Hikurangi Subduction Zone is among the most active regions globally for SSEs, yet Aotearoa New Zealand still lacks an automated system to monitor them in near real time. Current approaches rely heavily on expert inspection and computationally intensive inversions, which limit their operational use.

We present progress on applying geometric deep learning to GNSS time series for the nowcasting of slow slip. By leveraging both the temporal evolution of GNSS displacements and their spatial relationships through graph-based representations, our approach estimates the daily probability of anomalous slip along the Hikurangi interface. We investigate several graph-based neural architectures and find that they capture the complex spatial dependencies of slip more effectively than conventional methods.

Beyond characterizing SSEs, we emphasize interpretability and robustness. By analyzing the mapping between GNSS stations and slip sources, we identify which stations are most influential for detecting events in specific regions. We also explore strategies for handling missing stations and incomplete data, a key requirement for operational deployment.

This work represents a step toward automated, real-time SSE monitoring and nowcasting in New Zealand. The same framework could also contribute to the rapid characterization of large earthquakes, providing new opportunities to improve seismic hazard assessment and situational awareness along the Hikurangi Subduction Zone.

Agentic workflows: shaping the future of scientific software with AI

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Artificial intelligence is moving beyond chatbots into agentic workflows—systems that can plan, reason, and act on behalf of users within complex software environments. For scientific applications, this opens the possibility of not just answering questions, but directly running models, configuring workflows, and adapting outputs to operational and research needs. This presentation will explore how agentic workflows could transform scientific research software, drawing on early experiments at Earth Sciences New Zealand. One example is a prototype RiskScape AI Agent that can directly interface with the RiskScape hazard and risk modelling engine, running commands and guiding scenario testing. While these developments are at an exploratory stage, they highlight both opportunities and challenges: from accelerating uptake and lowering barriers to use, to questions of trust, reproducibility, and governance.

Advancing earthquake resilience: a multi-modal approach to analysing human behaviour

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The unpredictable nature of earthquakes creates significant uncertainty for communities in seismically active regions. These events can cause extensive damage, and people tend to exhibit distinct behavioural patterns during and after the shaking. Such behaviours are influenced not only by the intensity of the earthquake but also by cultural factors, emergency management protocols, environmental and social cues, and the built environment.

Previous studies investigating earthquake-related human behaviour have primarily relied on post-event surveys. While surveys are valuable for capturing demographic information and personal experiences, they are subject to memory bias. In contrast, analysing CCTV footage offers a unique opportunity to observe the true nature of people's actions. However, CCTV data often lacks demographic clarity and may be limited by environmental occlusions or poor visibility. Additionally, analysing CCTV footage is more challenging compared to survey data. Despite the complementary strengths of these two methods, a notable gap remains in research that systematically combines them to develop a more comprehensive understanding of behavioural responses during earthquakes. Advances in artificial intelligence (AI) offer new opportunities to analyse large volumes of video data efficiently and identify actions and movement patterns through deep learning. Although AI is increasingly used in behavioural sciences, its application in earthquake-related behavioural studies remains limited.

This study adopts a multi-modal approach, combining CCTV footage and survey data to investigate human behaviours during and immediately after a shaking. By examining how individuals respond to environmental and social cues, this research aims to identify behaviours that may increase the risk of injury. The findings are expected to support the refinement of existing earthquake response strategies and contribute to the development of evidence-based recommendations to enhance community resilience in Aotearoa New Zealand.

A decade on: reassessment of Kaikōura earthquake coseismic deformation via InSAR

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The 2016 Kaikōura earthquake in New Zealand produced one of the most complex surface rupture patterns ever recorded, with over 20 faults breaking the surface and generating widespread ground deformation. Since the outset, Interferometric Synthetic Aperture Radar (InSAR) has played a crucial role in analyzing this deformation. Nearly a decade later, InSAR methodologies have advanced significantly, with tools such as ISCE2 enabling more precise coregistration of SAR images and measurements of ground displacement.

To enhance our understanding of the coseismic deformation of the Kaikōura earthquake, we are using ISCE2 to regenerate interferograms and derive 3D surface displacement field from a comprehensive suite of Sentinel-1 and ALOS-2 SAR data.

In this presentation, we present our preliminary results. Surface deformation shows southeastward displacement of the Papatea Block, located west of the Papatea Fault, and left-lateral motion along the Papatea Fault. In addition, significant right-lateral movement is evident along the Kekerengu Fault, consistent with field observations and GNSS measurements. The complete 3D deformation mapping will allow us to reassess vertical and horizontal displacements at a better resolution, including right-lateral ground displacement along the Kekerengu Fault, shortening across the Papatea Fault, areas of uplift near the rupture, and subsidence inland of the ruptured faults.

Characterising cementation as a control on rock strength in the East Coast Bays Formation, Auckland

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The East Coast Bays Formation (ECBF), part of the Waitemata Group, is one of Auckland's most prevalent geological units, underlying much of the city's rapidly developed urban landscape. It is a flysch sequence of weak, interbedded sandstones and mudstones, which are highly prone to weathering and exhibit significant regional and local variability. These characteristics have long made the ECBF a problematic formation in engineering geology, with reported issues in slope stability, tunnelling, and construction across Auckland. While numerous studies have explored the challenges posed by the ECBF, there has been little focus on the critical role of cementation in influencing its strength and durability.

Focussed on Narrow Neck Beach, this study utilises a range of field and laboratory methods to investigate cementation in association with the strength of ECBF sandstones. In the field, Schmidt hammer rebound, P-wave velocity (PUNDIT), and Equotip surface hardness testing are used to assess variability between sandstone units. These measurements complement laboratory analyses of porosity, density, P- and S-wave velocity, and durability, alongside Scanning Electron Microscopy (SEM) with Energy Dispersive X-ray Spectroscopy (EDS) to examine the microstructural characteristics of the sandstones and how they may relate to strength and durability.

Through this integrated approach, this study aims to better understand the relationship between cementation and the geotechnical behaviour of ECBF sandstones, while also emphasising broader implications for understanding weak rock formations in applied geology. Improved characterisation of cementation will contribute to more reliable geotechnical decision-making in Auckland's complex geological setting.

Improving the performance of the FinDer algorithm for rapid characterisation of offshore New Zealand ruptures

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New Zealand has significant earthquake shaking and tsunami hazard from offshore sources, including the Hikurangi, Kermadec and Puysegur subduction zones, as well as numerous crustal faults. Due to the potentially short time (less than 30 minutes) for tsunami to reach coastlines, natural warning signs (“long or strong get gone”) remain the key to timely evacuation. However, rapid information about the rupture could be useful to guide ongoing tsunami modelling, situational awareness and response advice. The Finite-fault rupture Detector (FinDer) algorithm is designed to rapidly characterise earthquake rupture using template matching for the observed spatial pattern of high frequency, high amplitude ground motions. It has been operational in New Zealand since 2023 and has demonstrated reliable performance for onshore crustal sources. However, its methodology performs best with dense ground motion observations in the epicentral region, resulting in poor performance for offshore sources, especially when there is a large azimuthal gap in station coverage. FinDer is implemented in a number of systems around the world for earthquake early warning, including in regions with offshore seismic hazard, such as the USA West Coast ShakeAlert system and Central America, and it is being tested in Taiwan. A number of modifications have therefore been trialled to improve performance for ruptures outside of the monitoring network. This includes the use of fault-specific templates during template matching, which tests observations against possible ruptures on mapped fault geometries, and the use of source parameters from other algorithms. Here we present progress on implementation and testing of these algorithm developments using real and synthetic New Zealand offshore earthquake data.

More than water: Large-scale experimental facility for debris flow research

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Debris flows are destructive natural mass movement phenomenon capable of mobilising huge volumes of material at high velocities. While their hazards are well recognised, the transition from sediment-rich floods to hyper-concentrated mudflows remains poorly constrained, particularly in terms of internal structure and rheological behaviour. Large-scale experimental facilities provide the unique means to replicate debris flows under controlled but physically realistic conditions, allowing for high-resolution measurements of internal forces, physics, and processes.

We present the design and development of a new large-scale debris flow facility built to bridge the gap between small-scale analogue experiments and field observations. The flume features an adjustable slope (5-30 degrees), high-volume supply tank (400L), and fully instrumented channel. Embedded sensors – pore pressure, load cells, and 6-axis torque cells- are distributed across the channel to capture transient forces and internal vertical structures of the synthesised flow. The setup can accommodate a wide range of sediment mixtures, from hyper-concentrated (as low as 30vol% solid) to dense debris flow end-members (up to 70vol% solid), allowing for systematic variation of boundary conditions.

Scaling analysis underpins the design, ensuring that flows synthesised replicate the governing parameters of natural debris flow (i.e., Savage, Bagnold, Froude numbers, and relevant Reynolds regimes). Mixture properties, flow depths, and velocities are informed through past studies and from small-scale experiments to maintain dynamic similarities when possible.

The focus on hyperconcentrated flows is particularly relevant in the aftermath of Cyclone Gabrielle, which produced widespread flooding and extensive sediment mobilisation in Aotearoa New Zealand. By examining how flow structures and pore pressures evolve across the flood-debris flow transition, this facility will provide data that directly support the refinement of rheological models and the development of hazard frameworks for future extreme weather events.

The role of coal-magma interaction in the temporal development of magmatic plumbing systems: insights from the Ferrar Large Igneous Province

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The mechanical properties of the host rock in continental Large Igneous Provinces (LIPs) have a major control on the development of a LIP magmatic plumbing system by affecting how magma propagates through the crust via a range of brittle and non-brittle processes. Interaction between magma and carbon-rich layers (e.g. coal) in sedimentary basins is a fundamental process in many continental LIPs and is shown to release large volumes of volatiles into the atmosphere, affecting global climate and in some cases triggering mass extinctions. However, few studies have examined how volatile release from coal-magma interaction affects magma propagation and plumbing system development at the LIP scale. Using a range of structural measurements and field observations, we analysed the morphologies of Ferrar LIP dikes (183 Ma) emplaced in Beacon Supergroup sedimentary rocks across three sites in the McMurdo Dry Valleys, Antarctica, in order to determine their mode of emplacement in the crust. Tapered dike tips, stepped dikes, and dike-parallel deformation bands and fractures are commonly observed for the majority of dikes across the three sites, supporting brittle emplacement processes. However, we observe a noticeable transition to non-brittle behaviour in the Weller Coal Measures, where folding, faulting, and fluidisation of the host rock is observed adjacent to the dikes, and is also accompanied by a shift in dike morphology. We hypothesise that coal-magma interactions associated with both local- and regional-scale crustal heating from Ferrar LIP magmas resulted in large-scale volatile release and associated host rock fluidization, which encouraged non-brittle magma propagation. Our findings support an evolving host rock rheology for LIPs intruding volatile-rich sedimentary basins, which affects intrusion geometries, magma propagation processes, and the temporal development of LIP plumbing systems.

Say "Cheese!": an upgrade to the GeoNet volcano and landslide webcam monitoring capabilities

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Through the GeoNet program, GNS Science (now Earth Sciences NZ) has been using webcams to monitor natural hazards for the past 25 years. Cameras have been deployed permanently around five of our active or recently active volcanoes - Ruapehu, Tongariro Volcanic Complex, Taranaki Mounga, Whakaari White Island, and Rangitahua Raoul Island – for near-real time monitoring of volcanic unrest and eruptive activity. More recently, cameras have been installed along the Fox Valley/Fox Glacier area to understand mass-wasting and changes to glacial-geomorphology associated with glacial retreat. Until this year, cameras for volcano monitoring captured a still image every ten minutes (as seen at www.geonet.org.nz/volcano/cameras) and recorded low resolution video locally at one frame per second (accessible by manual download within ~2 weeks).

This year we began the deployment phase of a significant upgrade to our camera monitoring capabilities, allowing us to see in higher resolution, higher framerate, in real time (streaming video), and in lower light conditions, as well as paving the way for future installations of cameras outside of the visible spectrum (e.g. thermal infrared cameras).

Auckland maar lakes as recorders of Late Quaternary paleoclimate and tectonic events

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Continuous and high-resolution records of terrestrial paleoclimate spanning the Last Glacial Cycle (LGC: 117 kyr) are scarce from the Southern Hemisphere mid-latitudes. Consequently, the Auckland Volcanic Field (AVF) maar (crater) lakes are significant as they contain records of deep lake sedimentation that extend back to at least 193 kyr. These records are continuous and finely-laminated thereby allowing the identification of AVF and TVZ tephra, as well as evidence for abrupt climatic and tectonic events - in addition to multi-millennial-scale orbitally forced paleoclimatic variability. We have developed robust age models for Pupuke (ca. 0 to 50 kyr), Orakei (ca. 15.6 to 132 kyr) and Onepoto (ca. 9 to 193 kyr) maar lake sequences, with chronologies underpinned by multiple of AMS ^{14}C, luminescence dating, tephrochronology, magnetic paleo-intensity time-series and meteoric ^{10}Be influx. These well-dated AVF maar lake sequences provide the frameworks for developing high-resolution multi-proxy paleoclimate analyses from northern New Zealand that span at least the LGC. Our approach includes: a. micro-XRF scanning of the cores to identify sediment elemental variability and sediment influx events and the nature of their boundaries; b. organic matter TOC, TN, $\delta^{13}C$, and c. biomarker-inferred past temperature (GDGTs), and precipitation variability (leaf wax δD). This approach has enabled identification of climate teleconnections that span as far as Antarctica and the Southern Hemisphere subtropics. The well-dated laminated lake sediment records also contain signals of soft sediment deformation and sediment influx events that could have seismic or storm event origins that can be distinguished using our micro-XRF and associated microfacies approach.

Our-finely laminated and well-dated AVF maar lake sequences retain the properties required to identify not only past climate events and their timing, but also their drivers so that they constitute a rare and valuable high-resolution and continuous terrestrial record of LGC paleoclimate from the southwest Pacific region.

Recent explosive eruptive history of Tūhua volcano, Bay of Plenty: insights from marine cores

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Tūhua volcano (Mayor Island) is located ~25 km off the Bay of Plenty coastline and was the site of a major caldera-forming eruption at ~7.2 ka. Tūhua is unusual in its geographic location, being positioned ~80 km behind the line of active Taupō Volcanic Zone (TVZ) volcanoes, and erupts peralkaline rhyolite compositions with distinct obsidian margins to many of its lavas. While Tūhua's onshore geology has been well studied, the extent and ages of recent (Holocene) explosive activity remains uncertain, yet is important for understanding the volcanic history and associated hazards from this near-shore volcano. Our study investigates the young pyroclastic explosive eruptive record of Tūhua by examining 16 marine piston cores collected from proximal and medial sites to refine the numbers, ages, sizes, componentry, and compositions of eruptions. At least three distinct peralkaline tephra layers, ranging from several centimetres to tens of centimetres in thickness, were identified in the core records, particularly to the east of the volcano. In addition, a proximal core to the southwest of the island recovered meters of coarse pumice and mixed shell layers, likely reflecting debris flows associated with the 7.2 ka eruption. Mainland rhyolitic tephra layers from the mainland TVZ volcanoes have been identified, including the 1314 AD Kaharoa, 232AD Taupō, 5 ka Whakatane and 8 ka Mamaku events, providing additional bracketing age constraints to foraminiferal carbon dating. Initial results highlight the ashfall coverage and multiple explosive phases of the 7.2 ka caldera-forming eruption and also provide evidence for younger post-caldera explosive activity, poorly preserved in the island. Our revised Tūhua explosive eruption chronology will be used in conjunction with dispersal models to assess ashfall hazards for Bay of Plenty and North Island communities for future eruption scenarios.

The timing, nature and impacts of New Zealand's supereruptions

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New Zealand has experienced some of the largest explosive volcanic eruptions on Earth, particularly over the last 1 Myr, with three supereruptions at 25.5 ka, 349 ka and 1 Ma. Through a multi-disciplinary approach, we show that these events had significant impacts on climate, the New Zealand landscape and biota, with the timing and eruption style of each event playing a major role in the severity of the impacts. An investigation of the physical and chemical signatures of the 25.5 ka Ōruanui supereruption in multiple ice cores across Antarctica provides the first detailed study of sulfate deposition and flux from a supereruption. The sulfate anomaly, sulfur isotopic signature and presence of glass shards from this event varies between cores, reflecting differences in atmospheric circulation and deposit preservation, highlighting the challenges with interpreting volcanic signals in polar ice records. Like Ōruanui, the 349 ka Whakamaru supereruption also occurred during a glacial period but was at least three times larger volume, with welded ignimbrites in proximal deposits. Widespread airfall deposits from the Whakamaru event have been assessed and linked across the North and Chatham islands and in marine cores, indicating that multiple magma bodies were vented systematically through the eruption. Chemical signatures in deep ice cores suggest that this event may be preserved in Antarctic records, potentially providing new insights into the timing and climate context of this event. Finally, the 1 Ma Kidnappers supereruption also vented multiple magma types with an extremely widespread ignimbrite that covered a large portion of the North Island, along with extensive airfall deposits. New evidence suggests that this event was more complex and larger than previously estimated. We infer that supereruptions have played a major role in shaping the New Zealand landscape and may have also driven faunal turnover, influencing the distribution of fauna and flora.

Seafloor disturbance impacts on organic carbon storage in New Zealand's shelf sediments

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The seafloor plays a vital role in regulating the Earth's climate by storing carbon. Yet human activities like demersal fishing undermine the carbon storage function and still receive little regulatory attention. This oversight is often due to a lack of empirical data and uncertainty in first-order estimations of organic carbon mineralisation in resuspended sediments. Together with the low sampling resolution of the heterogeneous seafloor, it emphasizes the need for a simple, fast, reproducible quantification approach. We address this gap by presenting a new resuspension assay that quantifies oxygen consumption rates in resuspended sediments relative to undisturbed cores and converts them to organic carbon mineralisation to CO_2 using a respiratory quotient. Applying this assay on a wide range of sediments in the Hauraki Gulf, we identified organic matter content, coarse sand content, and geomorphological/ bathymetry-related features to influence resuspension effects on CO_2 production. Using the identified environmental characteristics in a gradient boosting machine learning model, we predict potential resuspension-induced CO_2 production for the Hauraki Gulf and the NZ shelf. The spatially extrapolated CO_2 production will help identify areas where sediment carbon storage is vulnerable to seafloor disturbance and thus provides crucial information for spatial fisheries management and designating marine protected areas. Our assay approach is notable for its simplicity and efficiency, offering a solution for assessing sediment resuspension impacts and promoting marine sustainability based on empirical measurements.

Fitted-clast textures in lacustrine fan delta mouth bar settings in the Cretaceous Paparoa Formation, Greymouth Basin

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Intricately jigsaw-fitted clasts can be seen in the Cretaceous-Paleocene conglomerates of the Paparoa Formation in the Greymouth Basin. The ~600 m thick section contains clast supported cobble to boulder conglomerates with sandstone lenses deposited in a lacustrine fan delta setting. The thick section of conglomerates contains abundant soft sediment deformation including load casts and convolute bedding indicating a subaqueous delta slope environment. Moderately to poorly sorted, clast supported conglomerates with coally interbeds indicates subaerial braided river deposits of the delta plain. Locally, lenses of pebble-cobble conglomerates are clast supported, contain no matrix, and are cross-bedded. The lenses are approximately 5-7 m wide and 1-2 m thick, stratigraphically between the delta slope and delta plain facies, and are interpreted as delta front channel mouth bars.

Clasts in the channels show jigsaw-like fitted edges with sharp contacts and angular indentations on clast interfaces. The clasts are composed of Greenland Group metasandstones and siltstones with vein quartz and granite present in minor amounts. The metasedimentary clasts are fitted tightly together regardless of the relative hardness of argillite vs metasandstone with examples of either lithology indenting the other. Intricately fitted beach boulders have been described for modern rocky shore platforms on a promontory with large waves. The interpreted process of forming tightly fitted clasts relies on in-situ abrasion from wave impacts on the cliffs causing jostling of the clasts until the intricately fitted contacts form. Much older studies of in situ abrasion in fluvial environments suggest the role of microvibrations from clast collisions and winnowing of fines in gravelly fluvial environments. The context of the intricately fitted clasts in the Paparoa Formation conglomerates in the delta mouth bar channels from high energy, steep alluvial fans into low energy lacustrine environments suggests that microvibrations and winnowing by currents may both be necessary.

Crustal structure and plate interface geometry along the Hikurangi Subduction Zone

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The geometry of the subduction megathrust and the properties of the overthrusting and subducting plates have been shown to play key roles in modulating the rupture area, slip-distribution and magnitude of megathrust earthquakes, and their proximity to densely populated coastal regions or deep-sea trenches. Constraining these parameters at both high-resolution and over scales comparable to the rupture area of the largest earthquakes (∼50,000–250,000 km2) is, however, a significant challenge.

In this presentation, I will describe how onshore-offshore, seismic reflection and passive seismic datasets are being integrated to constrain crustal and megathrust structure along the Hikurangi subduction zone.

The role of magma-flux on eruptive behaviour during the formation of the monogenetic Ubehebe volcanic centre, Death Valley, California

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Phreatomagmatic eruption styles are often attributed to the presence or absence of water, but we propose that magma delivery rates play a greater role in controlling eruptive styles and fragmentation depths. Low magma flux or magma withdrawal favours subsurface phreatomagmatic explosions and cratering, while higher fluxes feed fountains and high plumes with widespread fallout.

The Ubehebe crater cluster in Death Valley, USA, showcases how changes in magma supply shaped the weeks-to-months-long eruption from at least 14 vents ~ 2.1 ka. The eruption began with spattering and sporadic weak explosions along a N-S vent chain, ejecting large composite bombs (up to 2 m) along trend. As magma flux decreased, phreatomagmatic cratering formed the southern Amphitheatre Crater and emplaced surge deposits to the north.

Renewed magma supply focused to the north, draining magma from the southern fissure and initiating phreatomagmatic explosions that extended the Amphitheatre northward, before driving violent strombolian activity that constructed a scoria cone and deposited fall material over ~93 km². Subsequent magma withdrawal renewed excavation of the Northern Amphitheater crater, truncating the scoria cone. Briefly increased magma supply then fed fire fountaining that formed the Little Hebe spatter cone. Later, E-W aligned craters formed orthogonally to the Amphitheatre craters. Overlapping deposits from these craters were capped by a ~9 km² fall deposit from Crater P, before formation of the Ubehebe Crater maar, the final and largest crater, as magma continued to withdraw. This study highlights how magma delivery, rather than surficial hydrological changes, governs eruption progression and magma-water interactions.

Shattered records: fuel-coolant-interaction amplified ash fracturing in the 2022 Hunga eruption

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Fractography, the study of fracture surfaces, reveals the energy and mechanisms of material failure. Two principles underpin its application: (1) greater energy density generates more fractures, and (2) higher energy release rates increase fracture complexity. We applied these principles to basaltic to rhyolitic ash from eruptions and analogue experiments to assess damage fractures created by different fragmentation regimes to produce particles.

High-resolution backscattered electron images of ~63 µm ash grains (4 ϕ) from a Zeiss FEG-SEM were used to document fracture types and abundances. Experimental particles representing single fragmentation processes of thermal granulation, fuel-coolant-interaction (FCI), abrasion, and shattered Prince Rupert Drops were compared with natural ash from Surtsey, Havre, Katmai, Krakatau, Hunga, and Sakurajima. Eruptions involve multiple fragmentation processes, characterised together as a fragmentation 'regime' represented by their ash particles.

Using a Damage Fracture Intensity (DFI) index incorporating fracture prevalence, relief, complexity, and interactions with glass–crystal boundaries, we inferred relative energy densities and release rates for each process or regime. Particles from magma–water interactions consistently showed more extensive and complex damage than those from dry fragmentation. Up to 83% of Hunga particles display severe to extreme damage—more than any other eruption studied, including Krakatau 1883—matching only FCI experiment results.

FCI produces the most extreme damage of any known volcanic fragmentation mechanism. Unlike the tensile failure of magmatic or quench fragmentation, FCI involves microsecond-scale energy transfer, compressional failure, and shockwave propagation. Chaotic high-relief textures form above terminal fracture velocities, reaching 3360–5850 m/s, orders of magnitude faster than 2–70 m/s in magmatic fragmentation.

The high abundance of complex fractures in Hunga ash indicates exceptionally dense energy expenditure during FCI-amplified fragmentation. Such textures provide direct physical evidence of the extreme, ultrafast processes driving one of the most powerful explosive eruptions ever recorded.

Geoscience in the pursuit of energy resources – reflections

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To embark on a geoscience career in the 1970's was to catch a long-period wave that had started to form in the early stages of the Enlightenment – a continuously improving search for truths about the planet we inhabit. As knowledge became established, opportunities for those privileged to learn and strive to extend it arose in its application to exploration for, and development and exploitation of valued natural resources, not least energy resources including fossil fuels and geothermal systems. Accrued geoscience knowledge has also informed the treatment of natural hazards and those induced by development. The tension and balance between the three poles of geoscience purpose – knowledge, resource exploitation and hazard avoidance – has shifted continuously: I suggest a couple of significant turning points in the foci for geoscience, drawing on my own career, in a global and national context.

Early 1970's – Environmental awareness - "Limits to Growth" - and the oil supply crisis
About 2010 – a cluster of disasters including (in New Zealand) the Pike River coal mine explosion, and Christchurch earthquakes.

Climate change as a justification for science has gained increasing weight, especially subsequent to the Paris Agreement.

Recently it seems that the continuing search for fundamental knowledge has been discounted in favour of applications, and corrupted by imperatives to justify research by exaggerating its potential impact, whether in avoiding or mitigating threats, or in opening up and sustaining access to resources. It could be postulated that we are entering a descending "Disenlightenment" phase, contributing to, as much as reflecting, diminished public trust in science.   The profession needs to address such tendencies and emphasise objectivity to have any hope of sustaining the culture of science which served global society, and our nation well through its formative stages.

Improving GeoNet data useability: current and future enhancements through collaboration with internationalpPartners

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Making scientific data freely accessible is a key part of GeoNet's mission to provide FAIR, open scientific data. We want to better support access and exploration of our data by not just the scientific experts, but by the wider community including Iwi/hapū, schools and interested communities. To achieve this, we are exploring new approaches and tools to lower the barrier of entry for using and exploring our datasets.

Traditional methods of accessing and exploring scientific data typically require specific software and/or the technical knowledge to retrieve and use the data. GeoNet's recent efforts to work towards more user-friendly data access mechanisms included the Tilde data discovery tool. But those GeoNet datasets that are not distributed via Tilde remain not easily accessible by not-technical experts. To address this issue, we are exploring how to enable the exploration and use of data domains such as seismic data.

GeoNet's data tutorials are currently trying to address this, but their current form requires the skills and access to suitable technology to install and run Jupyter locally. We could support our users via hosting JupyterHub instances or similar, thus reducing the steps required to utilize these resources.

This work is done in collaborations with international data providers who are facing and developing solutions to the same issues. In pursuit of this Earth Sciences New Zealand, through GeoNet, is joining a partnership and collaboration framework between EarthScope (USA), Auscope (Australia) and EPOS (European Plate Observing System) to collaborate further on research infrastructure for geophysics and align approaches on data management, data sharing and technical standards.

Insights into the source faults of the Canterbury earthquake sequence from LiDAR differencing and elastic dislocation models

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New Zealand's South Island straddles the boundary between the Pacific and Australian tectonic plates. At the latitude of Christchurch, the plate motion is largely accommodated by the Alpine Fault, with approximately 25% of plate motion being distributed across the Southern Alps and Canterbury Plains. Despite this tectonic strain accumulation, prior to 2010, active faults in the Canterbury plains were largely unmapped due to thick fluvial deposits.

The Canterbury earthquake sequence (CES) involved four main earthquakes, with the most destructive event being the February 2011 earthquake in Christchurch City. The magnitude 6.2 earthquake originated under the Port Hills and resulted in NZ$40 billion in infrastructure damage and 185 fatalities. The CES encouraged efforts to map pre-existing and active tectonic structures throughout Canterbury, but the causative fault of the most damaging earthquake remains poorly resolved.

We use LiDAR differencing from surveys taken before, during, and after the CES to investigate pre-, co- and post-seismic deformation on the Port Hills' fault. We aim to improve on previous models of the Port Hills' fault and to explore potential post seismic slip, which could provide insights into the frictional properties of the fault during interseismic periods.

Our LiDAR differencing shows co-seismic uplift in the Avon-Heathcote area. In the years following the CES, subsidence is seen across southern Christchurch, however this may reflect non-seismic processes. The patterns seen in the LiDAR differencing will be used to interpret frictional properties of the fault and as an analogue for constructing fault plane geometries through dislocation modelling.

Geoenergy at the core: geoscience driving the global energy transition

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The global energy transition represents one of the most critical challenges of our time, demanding innovative and science-based solutions to ensure secure, sustainable, and affordable energy for all. Geoscience is central to this transformation, enabling the responsible use of subsurface resources for clean energy production, storage, and waste management. This talk will explore the principles and cutting-edge innovations in geoenergy systems, emphasizing their strategic role in complementing wind, solar, and other renewables to achieve a low-carbon energy mix. We will examine why accelerating the shift toward geoenergy is essential, addressing the combined pressures of climate change, finite fossil fuel reserves, and the urgent need to reduce greenhouse gas emissions and overall pollution. Through global trends and practical case studies, the presentation will highlight technologies such as shallow and deep geothermal systems, subsurface thermal energy storage, geological carbon sequestration, and the extraction of critical elements such as hydrogen, helium, and lithium from geothermal brines as integral components of resilient and flexible energy systems. Special attention will be given to their unique advantages, including round-the-clock reliability, small land footprint, and ability to stabilize renewable-based grids. Finally, the talk will consider the interdisciplinary dimension of this transition, bridging geoscience, engineering, and policy, and showcase how collaborative innovation can turn geoenergy into the core of sustainable energy strategies. This vision depends on technological innovation and the development of a highly skilled workforce, equipped to integrate geoscience, engineering, social sciences, and policy for transformative progress. By leveraging the vast potential of the Earth's subsurface, geoscience is already shaping a secure, sustainable, and low-carbon energy future, and its role will become even more critical as we advance the global energy transition with innovative and resilient solutions.

Inside pyroclastic density currents – first results of high-resolution measurements of their internal structure

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Pyroclastic density currents (PDCs) –ground-hugging multiphase flows of hot pyroclasts and gas – pose a frequent but poorly mitigated hazard at many volcanoes globally. The tragic 2019 eruption of Whakaari (White Island) recalls that even small-volume, low-energy currents pose significant risk and that all volcanoes in Aotearoa, New Zealand, can generate PDCs. As the main driver of PDC motion, the concentration and temperature of particles carried inside PDCs control their flow speed, destructive power, and reach. To predict and mitigate against PDC hazards, we must learn how the particle mixtures of PDCs move and sediment inside flows.

Here we present the results of the first high-resolution measurements of particle concentration, temperature and velocity fields inside large-scale experimental PDCs. We deployed vertical arrays of capacitance sensors and report a robust, non-linear scaling between capacitance and particle concentration that spans the entire spectrum from dilute to dense PDC endmembers. We show how cross-correlation techniques of pairs of capacitance sensors can be deployed in experimental and natural PDCs to probe the internal velocities of the opaque currents. The measurements were coupled with spatially highly resolved arrays of thermocouples to measure time series of vertical temperature profiles.

We show how the novel techniques enable imaging of near-continuous fields of the particle concentration and temperature of the experimental PDCs to reveal their enigmatic internal structure. Finally, we demonstrate how Reynolds decomposition techniques can be applied to the particle concentration and temperature data to resolve the most energetic coherent turbulence structures that control their flow and hazard behaviours.

Observations of faulting, folding and fluid flow in Rakaia Terrane greywacke, Princess Bay, Wellington, New Zealand

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Understanding past deformation in accretionary prisms is critical for interpreting present-day tectonic processes at convergent margins. During the Late Permian to Late Triassic, the Rakaia Terrane was accreted onto the Gondwanan margin. We present new structural and kinematic data from a field-based analysis of deformed Rakaia Terrane greywacke sandstone and argillite exposed at the Princess Bay shore platform, Wellington.

Structural orientations, kinematics, and cross-cutting relationships were mapped onto georeferenced, high-resolution orthophotographic imagery of the outcrop. Faults, folds, fabric, and veins are interpreted to preserve at least two phases of deformation. Maximum principal stress orientations, described in a present-day reference frame, shifted from a horizontal plunge and NNE trend in the first deformation event (D1), to a horizontal plunge and W trend in the second deformation event (D2).

Sinistral D1 faults follow bedding and strike NE, and NNE-striking D1 dextral faults are oriented at a low angle to bedding. The 2θ angle for conjugate D1 faults is relatively small (~30°). D2 conjugate faults cross-cut bedding and D1 faults. Sinistral D2 faults strike NW and dextral D2 faults strike NE, forming a large 2θ angle (~90°). The large 2θ angle exhibited by conjugate D2 faults is interpreted to reflect lower layer-parallel strength anisotropy and/or markedly lower effective normal stress during the second deformation event.

Quartz-filled fractures present throughout the outcrop display failure modes predominantly compatible with the D2 stress regime. A D2 upright, gently plunging, tight synformal anticline spans the 320 m-wide mapped area. An axial planar cleavage oriented 205/W/81 has developed within argillite-rich sediments in the hinge zone. Together, the mapped structures reflect deformation primarily associated with accretion and burial to maximum temperatures of 250-300°C and depths of 10-12 km in the Mesozoic. Princess Bay provides a well-exposed natural laboratory for future research of subduction-related fluid flow and structural processes.

Laboratory constraints on greywacke fault zone elasticity throughout the seismic cycle

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New Zealand faults most commonly occur in Torlesse Composite Terrane rocks, metamorphosed sandstone, siltstone, and mudstone. Our research tests how seismic cycle processes influence bedrock elastic moduli and seismic wave anisotropy.

Rakaia Terrane rock samples (n=67) were collected, prepared, and classified as representative of either the: intact pre-seismic, fractured coseismic/post-seismic, or sealed interseismic phase of the seismic cycle. P- and S-wave velocities measured using a benchtop oscilloscope were combined with measurements of grain densities and porosities to calculate elastic moduli. Intact samples have a 39.4 ± 3.82 GPa bulk modulus and 26.43 ± 1.5 GPa shear modulus. Fractured rocks exhibit a reduction in elastic moduli: 28.7 ± 6.78 GPa bulk modulus and 19.37 ± 3.07 GPa shear modulus. Interseismically, vein-forming minerals seal open fractures, and elastic moduli increase to intact values: 39.03 ± 3.72 GPa bulk modulus and 27.73 ± 2.08 GPa shear modulus.

The Backus modelling technique was applied to three different packages of vertical sandstone and siltstone layers to calculate their seismic anisotropy: (1) isotropic, intact layered sandstone and siltstone; (2) intact sandstone interlayered with sandstone layers containing randomly oriented fractures; and (3) a simulated fault zone with multiple fault cores surrounded by intact and sealed rocks. Alternating sandstone-siltstone layers produce minimal anisotropy (0.01%). Alternating layers of intact and fractured rock exhibit 2.5% P-wave anisotropy and 2.2% and S-wave anisotropy. The fault zone model produces a maximum P-wave and S-wave anisotropy of 17.3% and 9.5%, respectively.

Laboratory results show that seismic cycle processes, specifically coseismic fracturing and interseismic sealing through mineral precipitation, strongly influence the elastic moduli. Modelling results show that fractured rocks interlayered with intact and/or sealed rocks can produce seismic wave anisotropy. These results have important implications for mechanical, geophysical, and seismological investigations of fault zones.

Laboratory and thermo-mechanical modelling constraints on the seismic-aseismic transition depth, Wellington region, New Zealand

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Hydrothermal friction experiments performed on Pahau Terrane greywacke sandstone and siltstone gouges across a wide range of conditions (v=0.01 μm/s to 100 μm/s, T=20°C to 500°C, and σn'=75 MPa) show that the velocity-weakening to velocity-strengthening transition temperature, interpreted to represent the seismic-aseismic transition, is both lithology- and velocity-dependent. At the lowest velocities imposed, the transition temperature is ~450°C in sandstone gouge and ~350°C in siltstone gouge. Both lithologies are frictionally strong and velocity weakening in a narrow temperature range between T≃200°C and T≃300°C.

Applying the results to natural settings requires estimates of the geothermal gradient. We present 2.5-dimensional thermo-mechanical models for 2 transects across the Wellington region that incorporate subduction interface geometry and boundary conditions including strike-slip motion and asthenospheric flow. Models were run in two stages. First, long-term subduction effects on the upper plate were simulated with a 10-million-year setup phase with no upper plate faults. Then, after a 2-million-year deformation phase with upper plate faults, results were compared with observed geological and geophysical data.

Sensitivity analyses show that initial thermal structure, shear heating efficiency, and upper plate fault-interface geometries are the dominant controls on model outcomes. The models are broadly consistent with surface observations, although different starting parameters can produce similar present-day conditions. The predicted transition to aseismic creep via quartz crystal plasticity on the subduction interface roughly coincides with the observed up-dip limit of slow slip (~30 km depth).

In the upper plate, model-predicted geothermal gradients are ~15–18 °C/km. Assuming a 50% shear heating efficiency, the 300°C isotherm is inferred to intersect the interface within a few kilometres of the down-dip projection of the Wellington Fault on both modelled transects. West of the Wellington Fault, predicted aseismic creep in the lower crust reduces the likelihood that upper plate faults will co-rupture with the subduction interface.

Exploring science identity and sense of place through extra-curricular educational activities in favelas in Rio de Janeiro, Brazil

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As a post-colonial country, Brazil still carries the scars of over 300 years of colonisation. Inside the community of Cidade de Deus, or the City of God, in the West Zone of Rio de Janeiro, the Presbyterian Institute Alvaro Reis (INPAR) plays a vital role by offering marginalised students opportunities for socio-educational and recreational activities beyond regular school hours. Access to meaningful science experiences beyond the classroom is often limited for these students, therefore, we partnered with INPAR to carry out geoeducation as part of a new iteration of the social project Ad Astra Academy. For the 2024 edition, we restructured the project's curriculum to centre around place-conscious and cross-cultural activities for a small group of 11- to 17-year-old students. Some of the newly added activities, for instance, were informed by Aotearoa New Zealand's geological and cultural perspectives. This includes a virtual field trip through Aotearoa volcanoes and an introduction to pepeha as a way of locating oneself in relation to place, ancestry and identity. In this work, we present results from a pilot study that used a mixed-method approach to assess science identity and sense of place among Ad Astra students (n=11) and instructors (n=2). We performed pre- and post-test surveys with all participants, a Draw a Scientist Test (DAST-C) with students and post-project interviews with instructors. Quantitative and qualitative data suggest that, while students previously attributed stereotypical traits to scientists (e.g. an intelligent white male in a lab coat), Ad Astra positively impacted their science identity and attitudes. Students also showed slight changes in average place attachment (2.09, SD=6.46) and place meaning (-2.55, SD=9.06), while keeping overall positive scores. The results of this small-scale study provide, therefore, a basis for discussing the impacts of short-term interventions on complex constructs like science identity and sense of place.

Radiated seismic energy estimation tool for Aotearoa and the south-west Pacific

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Quantification about the energy release of an earthquake, including its amplitude, duration and frequency partitioning, is useful for understanding the nature and impacts of the event and, in some cases, can contribute to improved event response and disaster risk reduction (Venkataraman et al., 2006; Convers and Newman, 2011).

This increased understanding of earthquake sources has the potential to make a significant contribution to the Rapid Characterisation of Earthquakes and Tsunami (RCET) project, an ESNZ-led project t, which aims to characterise a seismic source within 10 minutes of its occurrence, improve estimations of earthquake damages and impacts, as well as assessing resulting hazards such as tsunamis and landslides, and further developing local communities' knowledge and resilience.
At the core of our assessment tool, we have used the method of Newman and Okal (1998) to estimate radiated energy at teleseismic distances, at the core of our tool. Using this technique, we have compiled an Aotearoa New Zealand regional catalogue of seismic energy estimations to fill gaps in existing studies. Based on this catalogue, we will be able to highlight the effects of local variation in the tectonic regime in the New Zealand region, to either confirm or refine what we already know from a geological perspective.

This presentation summarises the ongoing efforts of this work that aims to extend the tool's application. This includes refining the station selection, including stations at shorter epicentral distances for a faster and more constrained analysis during response (Convers and Newman, 2011; Ebeling and Okal, 2012), extending the studied region to the south-west Pacific and deeper earthquakes, and adding methods based on the near-field recordings (Boatwright et al., 2002) to the tool.

Illustrating uncertainty in natural hazard science advice: sharing Aotearoa New Zealand public survey results

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Uncertainty is a fundamental aspect of geoscience and geohazard data. The design of uncertainty visualisations, including choices related to color and visual emphasis, can significantly impact risk perception and confidence in forecasts. Studies have shown that uncertainty visualisations in health, weather, wildfire, earthquake, climate change, and volcanic data can affect interpretation. However, there is a gap in research on how to best communicate geohazard uncertainties to diverse stakeholders in New Zealand.

We present the results of an online public survey on uncertainty visualisation approaches and their different impacts on effectiveness and preference. We surveyed 300 New Zealanders testing different ways of communicating uncertainty on ashfall maps. We compared visual versus text uncertainty forecasts, maps with and without uncertainty, probabilistic and scenario maps, and maps which had different amounts of uncertainty displayed.

Our results showed that format of the forecast had a significant impact on how well people understood the uncertainty, how easy they found it to use, and how much they trusted it. Interestingly, text-based forecasts generally performed better, though visual forecasts did help people better understand the range of possible outcomes. We also found that including uncertainty on maps, and the degree to which it was shown, influenced decision-making, comprehension, ease of use, and trust. Adding uncertainty sometimes made it harder for people to make decisions. When it came to different ways of showing uncertainty, respondents preferred probabilistic maps over scenarios. Across all our experiments, it was shown that respondents often brought their own understanding of uncertainty to the decision making task, interpreting it in different ways. Adding more explanation alongside the uncertainty could help ensure future communications are effective.

Taking these results, along with a thorough look at existing research, we are now working on developing initial guidelines to assist anyone tasked with communicating uncertainty in scientific data.

Auckland rock as Mars analogue: effect of temperature and humidity on seismic velocities of sandstone and basalt

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Seismic data recorded on Mars from NASA's InSight mission provide valuable information regarding Mars' crust. Remote sensing evidence suggests the presence of humidity in Mars' crust, but how humidity adsorption affects seismic velocity at low temperatures is poorly understood. In this study, we use the Auckland Waitematā sandstone (39.6% porosity), along with the high porosity Snake River Plain basalt (18%; HP), and the low porosity Taupō Volcanic Zone basalt (10%; LP) as Mars analogue rocks. We performed a series of laser ultrasonic measurements under controlled humidity and temperature conditions on these rocks. We found that raising relative humidity (RH) from 10% to 90% at room temperature (~20 °C) reduces P-wave velocity of the sandstone by 30%, the HP basalt by 20%, and the LP basalt by 4%. Reducing the temperature to approximately -7 °C increases the P-wave velocity of the sandstone by 6% for the low RH setting and 27% for the high RH setting. For the HP basalts, the velocity increases by 10% at high RH setting but remains unchanged (within error) for the low RH setting. The velocity of the LP basalt is almost unaffected by temperature changes. According to numerical models, the adsorbed water either remains unfrozen at low temperatures or freezes away from the grain contacts, which minimally affects seismic velocity. Using the relationship between humidity and velocity from the experiments, and Mars' atmospheric data, we estimated a P-wave velocity change due to Mars' seasonal humidity variations to be similar to what is reported on Mars. Additionally, velocities from laboratory measurements coincide with Mars' crustal velocity model from seismic inversion, providing geophysical constraints for seismic interpretation.

Imaging the Auckland Volcanic Field using ambient noise tomography

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Auckland, the largest city of New Zealand, is situated on top of a young and active monogenetic volcanic field. The origin of this Auckland Volcanic Field (AVF) is still largely unknown as it is an atypical intraplate volcanic field not obviously linked to mantle plumes or tectonic processes. An international team of geoscientists has recently started an interdisciplinary study of the AVF with the goal to better understand the processes at play. A temporary new array of 20 broadband land and 20 ocean-bottom seismometers has been set up around Auckland and the data recorded are being used, together with the recently upgraded national network, to image the AVF.

Using ambient seismic noise, with frequencies filtered between 0.02 Hz and 2 Hz, we compute phase-stacked noise cross-correlations. We then extract dispersion information for surface waves between each pair of stations in our network with a wavelet transform algorithm. The dispersion curves are then inverted, through a 2-step inversion process using Reversible Jump Markov Chain Monte Carlo (rjMcMC) algorithms, to produce a 3D shear wave velocity model of the first 50km below the AVF. The structures observed are consistent with previous work on surface wave inversion and crustal body wave tomography in the region, and will be compared with known surface geology. Combining this method with P-to-S receiver function imaging and existing geological and geochemical information will allow for a more complete geodynamic modeling. The resulting model will help further constrain the causes of the upwelling of mantle material that resulted in the AVF.

Shear wave velocity image of an ophiolite nappe in New Caledonia and its implications for Eocene subduction initiation beneath Zealandia

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To illuminate our understanding of Eocene ophiolite emplacement and subduction initiation in northeastern Zealandia, we image shallow (0–3 km) shear wave velocity structures of and beneath an ophiolite nappe in southern Grande Terre, New Caledonia. We assessed the uncertainties of each dispersion curve to obtain stable dispersion curves at short periods (<1 s) from a network of 17 seismic stations, whose average interstation distance is ~15 km. Two velocity discontinuities were imaged at depths of 100 m and 400–800 m, representing surface regolith and the base of the ophiolite nappe, respectively. The ophiolite nappe is underlain by continental basement rocks in the centre of the island and sedimentary rocks on both the east and west coasts, respectively. The base of the nappe is generally flat but shallows at ~2.5° westward to the surface on its west flank. This east-dipping ramp of the ophiolite base is interrupted by a high velocity post-emplacement intrusive body, which is interpreted as the root of Saint Louis Granitoids. Based on the geometry of the base of the ophiolite nappe during emplacement, we suggest a down-going gravity-driven emplacement mechanism of the ophiolite nappe, which is similar to allochthon emplaced in the Reinga Basin and Raukumara Basin in northern New Zealand. The ophiolite nappe and the underlying bedrocks are likely more fractured on their east flank due to syn/post emplacement deformation and isostatic adjustment and present-day flexural bending.

Low felt intensity of earthquakes in the footwall of the Vanuatu subduction zone, New Caledonia, South Pacific

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Peak ground acceleration (PGA) data from accelerometers and broadband instruments in three networks in New Caledonia are compared with ground motion prediction equations (GMPEs). Deep subduction events recorded at Loyalty Islands have PGAs slightly greater than GMPE predictions, but shallow events have anomalously low PGAs. Deep subduction events recorded in Grande Terre fit GMPE predictions, but shallow events have anomalously low PGAs. Source effects are ruled out because PGAs on the overriding plate fit GMPE predictions. Mapped geology and horizontal-to-vertical spectral ratios indicate site amplification at some places in Grande Terre and Isle of Pines that explains some observed variability, but a local path effect (barrier to energy) beneath the shallow (<50 km) outer slope of the subduction trench is required to explain our observations. We propose that a shallow barrier of fractured hydrated lithosphere also exists beneath other subduction trenches. We have insufficient data to resolve if local barriers beneath Grande Terre or attenuation beneath the outer rise trade-off against low attenuation in the deeply subducted slab. A global GMPE for subduction outer rise settings is needed. Seismic hazard in New Caledonia is lower than predicted by GMPEs, but local magnitudes of shallow earthquakes and hence real-time tsunami hazard may be under-estimated using local observations unless this shallow trench path effect is accounted for.

A new hope: enhancing paleoseismic records of the Hope Fault using fault-contact lakes

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The Marlborough Fault System (MFS) is located in the northeastern South Island of New Zealand and serves as an intracontinental plate boundary transfer zone, connecting the Hikurangi Subduction Zone in the north, to the Alpine Fault in the south. The system accommodates approximately 38-40 mm/year of relative plate motion, the majority of which is taken up on four sub-parallel strike-slip structures: the Hope, Clarence, Awatere, and Wairau Faults. These faults have the potential to generate large earthquakes (Mw>7.0), as evidenced by historical events. However, our understanding of the likelihood that large earthquake sequences propagate through the MFS remains limited. Despite numerous paleoseismic studies, the ability to resolve earthquake sequences accurately using traditional on-fault trenching studies has been hindered by inadequate age control for the ruptures detected. There is a pressing need for new approaches that can provide definitive evidence of surface rupture, along with precise dating. Fault-contact lakes may present a promising opportunity to characterise the sedimentary signatures of fault ruptures within a depositional context that enables the development of high-resolution chronologies and precise earthquake age control. Horseshoe Lake is intersected by the Hope Fault (which last ruptured during the 1888 North Canterbury earthquake) and is an ideal candidate for evaluating this approach. This study will employ a facies-based, multi-proxy analysis of sediment cores from Horseshoe Lake to identify signatures of surface rupture, starting with the 1888 earthquake. Detecting these signals throughout the sedimentary record may yield longer and more accurate earthquake chronologies compared to those obtained from trench sites. Additionally, integrating data from other fault-contact lakes in the region and reconciling it with existing trench-derived data has the potential to significantly enhance our understanding of long-term earthquake recurrence and possible rupture sequences across the MFS.

“I’m constantly aware that I live next to a super-volcano”: Shifts in risk perception across a year of caldera unrest and storm events in Taupō

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Unrest at caldera volcanoes can have complex influences on risk perceptions due to the many variables, timescales, and uncertainties associated with unrest processes. Following several months of increased seismic activity, the Volcanic Alert Level (VAL) at Taupō volcano was raised to VAL 1 to indicate “minor volcanic unrest” in September 2022 – the first VAL raise at a caldera volcano since the system was introduced in New Zealand 30 years ago. Two months after the VAL was raised, we surveyed 506 people in Taupō and Rotorua about their perceptions of natural hazard risks and preparedness. Shortly after the survey was closed, the area experienced a M5.7 earthquake as part of the unrest. Three months later, the area was heavily impacted by ex-tropical Cyclone Gabrielle. Then, after seven months at VAL 1, Taupō volcano was lowered back to VAL 0 in May 2023 to reflect a return to background levels of activity. We repeated the survey in October 2023, 1 year after the initial increase to VAL 1 to explore changes in risk perceptions after the hazard events of the previous twelve months, receiving 225 responses. Here, we explore the results of these two surveys and discuss observed shifts and trends in risk perception across time. We then explore what the results mean in the context of managing and communicating long- and short-term risk in a dynamic hazard environment.

Controls on travertine and tufa deposition at Mt Taranaki, New Zealand

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This study presents the first comprehensive investigation of travertine and tufa deposits on the lower flanks of Mt Taranaki, integrating lithofacies, mineralogy, stable isotopes, trace element geochemistry, and a novel chronological framework. Travertine and tufa precipitation is linked to the emergence of CO_2-rich fluids along tectonic structures associated with regional faults and may be related to closed-conduit volcanic conditions preceding major Plinian eruptions. Carbonate deposition occurred between ~5190 and 1000 years BP on the southwestern flanks (Arawhata) and from ~3270 to 1190 years BP on the northeastern flanks (German Hill), coinciding with regional faulting and magmatic degassing events.

A new dating approach—combining radiocarbon analysis of organic residues with U–Th dating of carbonate matrices corrected for detrital Th using speleothem-derived $(^{230}Th/^{232}Th)_i$ ratios—overcomes the challenges of dating detritus-rich freshwater carbonates. Lithofacies evidence indicates widespread microbial mediation of carbonate precipitation, with aragonitic travertines forming under variable flow conditions and calcitic tufas developing predominantly in cool, low-energy spring environments.

Geochemical signatures of the precipitating fluids—including high Sr/Ba ratios, narrow $^{87}Sr/^{86}Sr$ values, and low $\delta^{13}C$—suggest that fluid circulation was largely confined to volcanic and shallow plutonic rocks, with minimal interaction with deep sedimentary formations. These findings support recent work by Werner et al. (2022) on the chemistry of contemporary springs at Mt. Taranaki.

Although modern spring waters remain supersaturated with respect to carbonate minerals, surficial travertine and tufa formation is currently negligible, likely due to anthropogenic lowering of the water table, land-use changes, and hydrothermal system evolution. This study provides new insights into the hydrological, volcanic, and tectonic processes controlling freshwater carbonate deposition in volcanic regions and highlights the sensitivity of these deposits to both environmental and anthropogenic change.

Speleothems as archives of volcanic eruptions: a high-resolution record from Mt Taranaki

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Speleothems are increasingly recognised as valuable archives of volcanism. However, most studies aim to detect large eruptions from distal sources using a few indirect chemical proxies, with few demonstrating a clear link to primary tephra fallout. Here, we undertake a rare opportunity to analyse the characteristics of volcanic particles contained within two stalagmites from a tufa cave to explore the tephrochronological potential of speleothems using Mt Taranaki as a case study. Stalagmites in this small, well exposed cave have an advantage over previous studies having formed proximal to the volcanic source (<13km from summit crater) along the main dispersal axis of most Holocene tephras from the volcano. The cave also has simple hydrology with thin epikarst meaning tephra and/or tephra derived signals can be rapidly incorporated into growing speleothems.

Tephra rich layers were identified in two young (1200AD–recent) stalagmites using 2D LIBS mapping followed by 1D LA–ICP–MS transects to determine trace element behaviour across event layers. Layers recording peaks in lithophile elements correspond to volcanic particles. Concurrent increases in fluid soluble elements suggests they were likely sourced from acidic leaching of tephra freshly deposited above the cave. Glass and titanomagnetites from two tephra layers were fingerprinted to the sub-Plinian Te Popo and Burrell events. A minimum of 10 eruptions were detected in the composite stalagmite record with new eruption timings determined using our refined U–Th age-depth model. Our eruption ages provide a similar, and in many cases higher, degree of precision compared with radiocarbon ages.

This unique dataset is significant as it provides a new, independent dating technique for recent Mt Taranaki eruptions and is anticipated to help refine eruption forecasting models for the Maunga. These results also have broader applications for speleothems as archives of volcanism, particularly in areas where proximal records are fragmentary and difficult to date.

Coastal sediment dynamics and coastal evolution in a changing climate

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Coastal areas are dynamic environments with a range of micro-to-macro scale processes contributing to their evolution. The response of coastal areas to a changing climate needs to be understood to minimise risk to communities, as well as to improve predictions of how coasts may evolve in the near future. The role that forcing factors, such as wind, swell, rainfall, or river discharge play on sediment dynamics within the coastal zone needs to be constrained. In New Zealand, approximately 65% of the population lives within 5 km of a coastline. Coastal suburbs, port facilities, transportation and utilities infrastructure, biodiversity, and recreation activities are all either directly or indirectly impacted by coastal change. Sea-level rise will affect the long-term viability of many New Zealand coastal communities. Work is currently underway to characterise sediment source-transport-sink processes in the Otago coastal region of New Zealand over a range of spatio-temporal scales, with the goal of understanding how the coastal environment is responding to anthropogenic actions and transitory sea-level change. Towards this goal, imagery from Sentinel 2 MSI has been bulk processed in Google Earth Engine, and Turbidity Indices have been created with short temporal resolutions for recent years. Initial results show seasonal to interannual variability of turbidity along the Otago coast, specifically the South Otago shelf. Semi-annual variability in turbidity and rainfall shows synchronicity. Terrestrial coastal LiDAR differencing shows that the majority of aggradation on South Otago beaches between 2004 and 2021 happened within 10 km of rivers of an order 6 or greater, whereas mostly erosion occurred at greater distances. Future aims are to incorporate shoreline advance/retreat assessment, geophysical shelf sediment store models, and oceanographic modelling.

Genetically and temporally grouping Holocene lavas and tephras at Mt Ruapehu

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Geologically recent (<23 ka) eruptions at Mt Ruapehu have produced both explosive and effusive products; however, there are very few historical examples of simultaneous explosive-effusive activity. This study aims to identify geochemical, temporal, and spatial (vent location) relationships between recent (<23 ka) tephras and lava flows. We focus on the late Mangawhero (23-15 ka) and Whakapapa (<15 ka) formations, which have recently been dated and constrained by regional tephrostratigraphic relationships.

We compiled a database of 85 bulk tephra compositions from 11 subunits, 319 lava flow compositions from 15 subunits, and 73 pyroclastic density current bulk compositions from 22 subunits, integrated with new X-ray fluorescence data from 14 tephra samples from 9 subunits. We first correlated the lava flow, tephra, and pyroclastic density current compositions using Euclidean distances and principal component analysis. These results were then integrated with temporal constraints and, where available, vent locations.

Preliminary findings indicate that correlating lavas and tephras using geochemical and temporal relationships is possible at Ruapehu. We have identified 22 potential tephra-lava flow pairings, although in some cases multiple possible correlations exist between individual tephras and lava flows. Further work is needed to establish whether geochemical, spatial and temporal similarities support eruption scenarios involving both effusive and explosive activity. Understanding the potential for compound hazards during future eruption scenarios is critical for improving multi-hazard forecasting and developing more effective hazard mitigation strategies.

The journey of GeoNet data

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What does it take for a GeoNet data packet to travel from sensors across Aotearoa New Zealand to the fingertips of users?

GeoNet is the national land and geohazards data and monitoring system, operated by Earth Sciences New Zealand in partnership with MBIE, NHC, LINZ, and NEMA. It manages more than 1200 sensors across Aotearoa New Zealand and the wider south-west Pacific. These sensors continuously measure ground vibrations, slow and rapid ground deformation, coastal and lacustrine water levels, volcanic gas emissions and temperatures, environmental conditions in landslide-prone areas and variations of the Earth's magnetic field.

These measurements are transmitted via a diverse and resilient telemetry network, collected, curated and processed through a complex web of systems running on cloud-based infrastructure. Raw data are paired to sensors metadata, transformed, organised, archived and further processed to generate derived and analysis ready datasets in near-real time.

GeoNet disseminates these datasets to end users through a suite of services, including near-real time data feeds, programmatic interfaces, and interactive dashboards for data exploration and visualisation. GeoNet's user base spans emergency management agencies, commercial clients, national and international scientists, data centres and universities.

This poster explores the journey of GeoNet data, from sensors to access points.

Open data is not enough: questions on Māori data governance in the context of national scale research infrastructure

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FAIR (Findable, Accessible, Interoperable, Reuseable) and open data principles are now commonly implemented in science data management. In the western science context, these principles can cause siloing and exploitation of Indigenous knowledge and practice in relation to data governance and collaboration. Many western (geo)scientists are unaware of CARE (Collective benefit, Authority to control, Responsibility, Ethics) principles, describing how to manage Indigenous data. Unlike FAIR, which are data-focused, these principles are people- and purpose-focused. They can be in tension with FAIR and open data, leading to a complex interplay between Indigenous data sovereignty, FAIR and CARE.

In Aotearoa New Zealand, CARE data principles are well understood in some research areas (such as Māori research) and adapted to Māori world view by Te Kāhui Raraunga (TKR) and the Data Iwi Leaders group. The vision of “Data for self-determination" is central to the Māori data governance model (Kukutai et al., 2023), a foundational guide for Crown agencies to uphold Te Tiriti partnership in the data space.

At a local level, scientists have successfully co-designed research projects with Iwi and hapū, resulting in mutually empowering collaborations. However, for large-scale, national data infrastructures such as GeoNet (operated by Earth Sciences NZ in partnership with MBIE, NHC, LINZ, NEMA), co-designing and upholding Māori self-determination remains limited and complex.

GeoNet currently provides open access to a wealth of data about the whenua and taiao that can and should be recognised as Māori data. Open data, public good and partnership are driving principles for GeoNet, but an open data policy alone is insufficient to enable hāpu, Iwi, and Māori to benefit from these data. In this poster, we won’t provide any answers. Instead, we would like to present our questions, asked from a tauiwi perspective, and a genuine desire to learn from Māori experts and do better.

Rockology Psychology, Taranaki Regional EarthFest: budget of none

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The opening of 'Whakarūamoko: Active Earth' at Puke Ariki Museum in New Plymouth, August 2025 provided a unique opportunity to strike while the iron was hot and offer to host a public open day to celebrate the Earth Sciences. Gather momentum and roll like a stone, jump in 'boots n all' and throw a Regional EarthFest while the team was on a high.

But on a budget of….. zilch. How do you hold an event requiring significant time and focus without any time for funding applications or practical considerations, like life? Welcome to Rockology Psychology 101.

Science on a shoestring. No joking matter and a very real situation for amateur outreach educators. Were we prepared for the task we had so enthusiastically suggested to the museum that we host? The first hurdle, realised a little late, required mental grit and acknowledgment of challenges yet unseen.

Appealing to the needs of our network and climbing steeply onto the backs of those who are paving the way with the National GSNZ EarthFest, we piece by piece tackled the jigsaw and prepared.

Whakarūamoko – Active Earth: a geoscience journey in community learning

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Early in 2022 Puke Ariki Museum New Plymouth kicked off the refresh of the Level 2 'Geology Corner' that had been in place since the museum opened in 2003. A simple refresh became a three-year journey reaching fruition and opening to the public in late August 2025.

An opportunity to contribute to the permanent exhibit was unexpected and exciting. Even more unexpected was the discovery that two years in, there was a near complete vision created without a geoscientist. The narrative behind the new exhibit favoured a local culture and curriculum-based approach to knowledge over scientific geological fact, all with the best intentions. There was no space to influence the content or design.

Or was there?

Although tempted to run away, SeisMomentum stepped in and had a deep dive into curation and education, and on how tempering expectations is applicable at every level of a permanent community project. Come along as we outline our learning of the problems, compromises, successes and solutions to get Whakarūamoko: Active Earth open to the public, in what could be quite literally titled - Grasping at Rocks.

Seabed 2030 and advancing ocean mapping: project updates and goals for 2026

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In 2017, the Nippon Foundation and General Bathymetric Chart of the Ocean (GEBCO) established the Seabed 2030 Project; tasked with building the necessary technical, scientific, and management frameworks to compile all available seabed mapping information into a seamless digital map of the world's ocean floor by 2030. Over the following 8 years, the Seabed 2030 Project has continued to accelerate our understanding of the worlds oceans through the annual release of global bathymetric compilation grids and maps for public use. In 2021, Seabed 2030 was officially endorsed as a flagship programme of the UN Decade of Ocean Science for Sustainable Development and in 2024 was selected as a Scale-up-Program (SCUP) by the Paris Peace Forum, highlighting the international impact of the project.

The Seabed 2030 project is now in its 9th year and has already received numerous new datasets for integration into the 2026 release of the GEBCO grid. Here we present an overview of the Seabed 2030 project, global seafloor mapping progress-to-date, and project goals for the next year.

An overview of marine imaging/sampling capabilities for geoscientific research

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The establishment of the public research office Earth Sciences New Zealand in July 2025 represents one of the most significant changes to New Zealand Inc. Science capability in more than 30 years. With the merger of the Crown Research Institutes GNS Science and NIWA and the eventual integration of Metservice, there will be significant changes in research program contracting, institutional structure, scientific equipment investment, and overall strategic directions to consider into the future. For the New Zealand geoscience community, it is therefore important to have access to a clear overview of existing scientific capabilities during the transition process for the new research entity.

Here, we present a strategic overview of Earth Sciences New Zealand’s existing marine/seafloor imaging and sampling capabilities, highlighting available research vessels, multibeam echosounders, seismic systems, towed camera technologies, archived bathymetric datasets (both processed and raw data), sediment grabs, corers, and other associated systems.

These assets establish a strategic foundation for Earth Sciences New Zealand to drive future directions in marine geoscience, while providing a platform for broad collaboration across the national and international research community.

The 2025 seismicity along the Puysegur Subduction Zone: what it can tell us about subduction processes and interplay with crustal faults

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On the 25th of March 2025, a M6.8 earthquake shook the lower South Island. This earthquake originated underneath southwestern Puysegur Bank and induced a 10 cm high tsunami at Puysegur Point, but besides that, the effect of the main shock was limited. Since then, several moderate- to large-sized earthquakes have occurred on and around the Puysegur margin, with five events being larger than M5.0 and two of them reaching M6.0 and above up to the 8th of July. These earthquakes are distinct from the direct aftershock sequence related to the M6.8. However, most of them occur around the Snares Depression and surrounding areas and have their own aftershock sequences, indicating that the margin is undergoing a stress redistribution on both the subduction interface and the overlying crustal strike-slip faults.

We present data on the M6.8 main shock and the first related M>5.0 event (M5.7 on the 29th of April) and their respective aftershock sequences by using a combination of seismic deployments, including our own PTANGO network (Puysegur Tremor and Nucleation Geophysical Observatory). The main earthquake and aftershocks have been detected using a deep-learning algorithm, an automated phase associator and have been manually reviewed. Robust locations are obtained using a non-linear location algorithm with an updated nation-wide 3D velocity model, and improved using relative relocation. We also compile data from other sources regarding the other recent earthquakes along the margin. We use these data and compare them to a larger four-year-long dataset to investigate where the M6.8 and its aftershocks occurred in the system, whether it be in the overriding or subducting plate or at the interface. We also discuss how the location influences our view on subduction along the margin and how crustal strike-slip faults in the overriding plate are interacting and accommodating some of the strain along the system.

A Fiordland deep-learning earthquake catalogue: deep-dive in its construction and observations

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The Puysegur Subduction Zone poses a potential tsunami hazard for most of the New Zealand coastline, as even relatively small earthquakes can generate a tsunami. For example, the M6.8 earthquake on the 25th of March resulted in a 10 cm tsunami being recorded at Puysegur Point. However, the likelihood of larger tsunamogenic earthquakes at the Puysegur Subduction Zone remains poorly understood. In addition, the region is of global tectonic importance as Puysegur is transitioning from incipient to more mature subduction. Despite the significance of Puysegur for both New Zealand and global science, our understanding of the region's seismicity, structure and stress state remain largely obscured by Fiordland's rugged nature and the fact that most of the margin is located offshore.

Using data from the GeoNet network and various temporary seismic deployments, we present a high-resolution earthquake catalogue for Fiordland containing over 30,000 earthquakes during a four-year-long period (2018-2019 and 2022-2024), and also includes data on the M6.8 earthquake and its aftershocks earlier this year. The catalogue is constructed using a deep-learning detection algorithm, automated event association and manual evaluation. Earthquake locations are obtained using the national 3D seismic velocity model and are improved through relative relocation. Combining these earthquake observations with focal mechanisms, we present new constraints on the region's seismicity and the geometry and structure of the subduction zone. This includes observations on the transition from a strike-slip dominated system in the south, to one of oblique subduction south of Fiordland, to oblique continental collision along the Fiordland coast, where the subducted slab is deformed at depth, with possible buckling happening within the plate, as it meets the Alpine Fault and the subducted Hikurangi Plateau.

High-resolution pseudo-3D seismic reflection imaging of the sedimentary infill of Lake Whakatipu

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Lake Whakatipu occupies the over deepened basin carved out by the Whakatipu glacier over several glacial cycles. Since the retreat of the glacier the lake has acted as a large sediment trap recording the paleoenvironmental and tectonic history of the catchment. Up to 500 m of sedimentary infill has been imaged using 2D multichannel seismic reflection surveys. Within this sediment, features such as the present lake floor channel, numerous ancient, infilled lake floor channels (paleochannels), landslide deposits and gas pockets have been identified in individual lines, showing the transition from a periglacial environment to the modern alpine environment. These features also indicate potential links to mass sediment transport events triggered by significant events such as Alpine Fault earthquakes.

Based on these initial results, a pseudo 3D multichannel seismic survey with 25 m line spacing was collected from the southern part of the Glenorchy Arm in Lake Whakatipu. The aim of this survey is to produce a 3D volume, where horizons, particularly paleochannels, can be traced across multiple lines. On going data processing and interpretation will gain insight into the historical formation and behaviour of the lake floor channels and their correlation to increased sediment transport following Alpine Fault earthquakes or other smaller events. Other features such as landslide deposits and changes in seismic facies identified in the seismic data will provide further insight into the paleoenvironmental history of Lake Whakatipu.

Imaging upper mantle structure beneath Earth's hidden continent of Northern Zealandia with ambient noise tomography

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Zealandia, the Earth's youngest and thinnest continent located in the southwestern Pacific, has 94% of its area (~4.9 million km²) submerged below sea level, earning it the title of the "hidden continent." This study focuses on northern Zealandia, a region that has experienced significant continental rifting and crustal thinning, yet the characteristics of its upper mantle structure and its connection to continental extensional mechanisms remain unclear. Aside from New Zealand's North and South Islands, deep structural studies of this submarine area are extremely limited, lacking direct constraints on upper mantle structure and tectonic evolution. Because seismic activity in this region is sparse (mainly around plate boundaries like Tonga-Kermadec and New Hebrides trenches), traditional body-wave tomography methods are difficult to implement, making ambient noise tomography a practical approach for examining the upper mantle of this concealed continent.

This study employs ambient noise tomography to obtain the shear-wave velocity structure of the upper mantle beneath northern Zealandia. Considering station distribution, duration, and quality, we use seismic noise data from 131 stations collected between 2010 and 2025, covering eastern Australia, New Zealand, New Caledonia, Fiji, and nearby Vanuatu. Ambient noise cross-correlations are computed using the NoisePy package with spectral whitening and phase-weighted stacking. High-quality fundamental-mode Rayleigh wave dispersion curves are extracted at periods of 20–100 seconds using frequency-time analysis (FTAN), enabling surface wave inversion to build a new upper mantle shear-wave velocity model.

These results reveal the detailed velocity structural characteristics of the upper mantle beneath northern Zealandia, highlighting significant differences from the Australian continental upper mantle. Furthermore our new model can provide important constraints for understanding the deep geodynamic processes of this hidden continent, such as the extreme continental extension mechanics, and the deep driving forces behind Zealandia's separation from Gondwana.

Characterising paleosols within tephra sequences in the Taupō Volcanic Zone

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The Taupō Volcanic Zone (TVZ) is noted for large explosive eruptions throughout the Quaternary period, which continually altered the landscape. These events have repeatedly buried past landscapes and associated soils under copious volumes of pumice-rich deposits, freezing the soils in time and forming paleosols (buried soils). The current topsoil of these 'pumice lands' are considered infertile and unattractive and are often limited to forestry. Exposing more fertile paleosols at the surface might present new possibilities for future land-use.

This research will combine pedology with volcanology to investigate the physical and chemical properties and carbon stocks of the most prominent buried soil horizons within the volcanic sequences for potential alternative land-use options. Temporal and spatial variations within soils of diverse ages, from the Last Glacial Maximum to the present day, and topographic, environmental, and volcanic influences on soil-forming processes will be examined.

Analysing soil chemical properties will provide insights into how climate variations over the last 26 kyr have affected soil formation and microbial activity. The influence of the two youngest active rhyolitic calderas exposed soil formation to variations in eruption frequency and magnitude, determining the length of soil development intervals, while varying input of andesitic tephras in the southern region of the study area impacted the chemistry for soil formation. Variations in regional climate and local topography further contributed to tempo-spatial diversification in soil chemistry and properties across the TVZ.

The chemical and microbial data provides a fundamental framework of soil characteristics and evolution that will be used to investigate two promising soils in more detail, including conducting excavation trials to test alternative land-use options. This research will contribute novel knowledge on how the exposure of paleosols influences key characteristics such as soil texture, water-holding capacity, microbial respiration, fertility, and subsequent root/plant development, as well as their carbon gain/loss potentials.

A model of Cretaceous subduction cessation and intraplate volcanism, based on South Zealandia 3D crustal structure

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The Hikurangi Plateau has played a fundamental role in Cretaceous subduction cessation and subsequent Zealandia tectonics. This study investigates South Zealandia 3D crustal structure and develops a 3D conceptual model of Cretaceous subduction cessation and volcanism associated with slab detachment. NZ-wide 3D velocity models are expanded to include offshore eastern South Island by utilizing shots from offshore seismic surveys that were fortuitously recorded onshore by the Otago passive seismic network.

Results show that uniform velocity Otago Schist crust (Mesozoic accretionary wedge) can be traced at least 20-40 km offshore. A zone of crustal intrusions bordering the schist is inferred from an ~100-km-long region of high velocity at 15 km depth. This zone includes the industry exploration well Caravel-1 in which Late Cretaceous granite was sampled, part of widespread syn-rift magmatism and intrusive underplating inferred under the Great South Basin. The thick underplated Hikurangi Plateau salient underlies most of the South Island. Its western edge coincides with the Alpine Fault, and its eastern edge transitions to a 100-150-km wide zone of oceanic crust still present beneath the Otago Schist. In contrast, the Median Batholith Mesozoic arc is not underplated by oceanic crust.

During the late Early Cretaceous (~110 Ma), the narrow Hikurangi Plateau salient experienced flatter and slower subduction than adjacent sections of oceanic crust and began to deflect the formerly linear Median Batholith into the Fiordland oroclinal bend. Trench rollback to the north of the plateau favoured extension and deformation in the proto-Alpine Fault corridor and North Zealandia. After the subduction zone was jammed by the entire width of the Hikurangi Plateau, the complex subducted plateau and slab geometry allowed spatially varied necking and detachment at 100-300-km depth. Regions of enhanced Late Cretaceous (~100-80 Ma) syn-rift volcanism could have resulted from asthenospheric upwelling around the plateau salient following slab detachment.

Monitoring Ruapehu the old-fashioned way

Peter Otway

This poster discusses and illustrates the way in which Ruapehu volcano was monitored in the pre-GPS and satellite era. Regular crater lake inspections were made on foot prior to the major 1995-96 eruptions, including deformation surveys across the crater rim from 1970 onwards, to assess its current and immediate future level of activity. Seismic monitoring was basic at first but was steadily upgraded as time went on. The hazard posed by eruption lahars through the Whakapapa skifield was also assessed for DOC and Ruapehu Alpine Lifts - and reported just one month before being tested by the 1995 eruption. Surveys to assess the potential for a major escalation of the activity were carried out during the eruption, and also to assess the obvious potential for a breakout lahar following the final, 1996, eruption. This finally occurred in 2007 with no injuries or major damage, unlike the 1953 Tangiwai disaster, thanks to DOC's careful planning.

Improving ground motion prediction in New Zealand earthquakes with Bayesian hierarchical modelling

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Accurately predicting earthquake ground motion intensity is essential for Earthquake Early Warning (EEW) systems, which aim to provide critical lead time before damaging S-waves arrive. In New Zealand, where seismic risk is high, improving the reliability of such predictions is of particular importance.

This study uses strong-motion data from GeoNet (GNS Science), including over 29,000 waveforms from more than 9,000 New Zealand earthquakes (M > 3.0) recorded at 293 stations between 2013 and 2022. Such a large and diverse dataset enables robust investigation of both event-level and site-specific variability.In earlier work, I applied linear multilevel models to this dataset to explore the predictive relationship between P-wave characteristics and S-wave intensity. While these models provided valuable insights, their reliance on restrictive distributional assumptions limited uncertainty quantification and robustness.

Here, I extend the analysis using a Bayesian hierarchical modelling framework with Student's t-distributions. This approach allows incorporation of prior knowledge, provides greater robustness to outliers, and delivers richer uncertainty estimates. The hierarchical structure explicitly represents three levels of variability: earthquake event (level 1), recording station (level 2), and site class (level 3).

The study has three main objectives:

1. To assess the role of site class in predicting S-wave intensity from P-wave characteristics.
2. To quantify the influence of station-level variability on predictive performance.
3. To evaluate which P-wave parameters—peak acceleration (Pa), velocity (Pv), or displacement (Pd)—are most informative for prediction.

Preliminary findings suggest that Bayesian hierarchical models yield improved predictive performance compared with classical multilevel approaches/ linear regression approaches, while offering more reliable measures of uncertainty. This highlights the potential of Bayesian methods for advancing EEW systems in New Zealand, helping to bridge statistical modelling with practical seismic risk mitigation.

Origins and timescales of tephra emplacement generating the Mangatawai Tephra, Tongariro National Park

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The timescales and periodicities of long-lived andesitic eruptive episodes, particularly those in the southern Taupō Volcanic Zone, New Zealand, remain poorly constrained. Understanding how long volcanism may persist and the recurrence intervals of events is vital for future hazard management and ongoing risk assessment. The Mangatawai Tephra is a distinct and widespread andesitic ash unit found throughout Tongariro National Park, and has been linked to eruptive activity from Tongariro and Ruapehu between ~3000 and 1800 years BP. At the Mangatawai Stream on the Desert Road, the type locality of the Mangatawai Tephra, the unit is composed of 0.19 m of dark brown fine ash, overlain by 0.5 m of dark grey medium ash, with interbedded grey and dark grey medium ash layers, containing abundant beech leaves. This research aims to refine the eruption chronology and internal stratigraphy of the Mangatawai Tephra through a combination of field-based, high-resolution eruptive stratigraphy and microanalytical geochemical techniques (EPMA, LA-ICP-MS, TIMS). Fieldwork will target key reference sections for detailed logging along different dispersal axes, compiling bed thickness and grain size measurements, and identification of internal stratigraphic units. A key objective is to determine whether the deposit formed predominantly during a short-lived phase of high activity or more gradually over the total eruptive span. Radiocarbon dating of beech leaves sampled systematically throughout the formation will be used to constrain eruption timing and relative rates of deposition across the different stratigraphic units. Geochemical analyses will be undertaken on groundmass glass and minerals to further pinpoint the eruptive sources and magmatic conditions, and to relate units to more proximal lava flows, including those from Ngāuruhoe. Refining the age and structure of the Mangatawai Tephra will strengthen local stratigraphic frameworks and contribute to broader Holocene tephrochronology and volcanic hazard assessment in the southern Taupō Volcanic Zone.

Spatial variations in and sedimentological characteristics of the Taupō ignimbrite

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The Taupō ignimbrite is a widespread (~20,000 km²), non-welded ~30 km³ ignimbrite that was emplaced during the final, climactic phase of the c. 232 CE Taupō eruption. The extent of the deposit as well as its sedimentological characteristics reflect an extremely rapid and energetic deposition from a relatively concentrated pyroclastic density current (PDC). The PDC travelled 80±10 km radially from source: topographic relief (to 1.5 km above vent level) had little effect on the distribution of the flow with the only barrier high enough to divert it being Mt. Ruapehu.

The ignimbrite displays two main lithofacies, layers 1 and 2, that were emplaced by the PDC flow head and body, respectively, as it travelled across the landscape. The spatial variations in these lithofacies (and their sub-facies) reflect changes in the flow processes as it coalesced and evolved throughout its runout length. The characteristics of the ignimbrite were also affected by the paleo-landscape with factors such as slope angle, altitude and vegetation playing a role in the appearance and sedimentological characteristics of the deposited material.

This study will map out detailed spatial variations of the Taupō ignimbrite based on its sedimentary characteristics. Areas of contrasting topography and orientation from source have been selected to determine the influence of internal and external factors on transport and emplacement mechanisms of high-energy PDCs.

Here we present preliminary field results from the Lake Taupō Forest and Kaingaroa Forest to the east of Lake Taupō. The collated field data and grain size distributions show great variation in the characteristics of the ignimbrite based on the relief of the underlying topography, distance from source and orientation from source. Further steps will involve analysis of the ignimbrite at its most distal extents to develop the understanding of depositional mechanisms within large, energetic PDCs.

Integrated pedestrian-car agent-based models for tsunami evacuation

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Aotearoa New Zealand is exposed to tsunamis from distant, regional, and local sources. Near-field tsunamis generated in the Hikurangi Subduction Zone with limited time before the arrival of the first wave pose a significant threat to communities along the eastern coast. With nearly 430,000 people living in tsunami-risk areas, rapid evacuation is crucial to minimizing losses.

During a tsunami evacuation, to decide upon a means of transport, evacuees weigh factors such as family needs, distance to the safe zone, and time of the day. Considering New Zealand's high per capita car ownership rates, if many individuals evacuate by car, a sudden high demand on roads could trigger traffic congestion and delays.

To quantify traffic bottlenecks and evacuation delays, integrated pedestrian and car agent-based models considering inter- and intra-modal interactions are under development for New Brighton, Napier and Gisborne. Intra-modal interactions such as pedestrian-pedestrian follow a speed-density relationship in the agents' field of view, while car-car interactions are accounted for with a car-following model. Inter-modal interactions such as pedestrian-car and car-pedestrian are included by detecting cars in the field of view of pedestrians, and by expanding the car-following model to include pedestrians. As a future work, model validation is planned against real-world data collected in New Brighton in July 2025. The model's pathfinding routine calculates precomputed routes with the A-star algorithm using heuristics that dynamically mark grid cells as impassable, useful to simulate a post-earthquake environment.

With the current A-star routine, simulations of the Westshore domain in Napier indicate that the SH1 route is underutilised. With most of the traffic moving towards Pandora Rd, unrealistic traffic jams cause excessive evacuation delays. To distribute the traffic among those routes, a varying cost routine that assigns lower costs to main roads is under development.

Science advisory panels: enhancing decision-making in New Zealand's emergency management system

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The science system plays a critical role in enhancing New Zealand's emergency management system across the 4Rs – reduction, readiness, response, and recovery. Integrating science advice not only strengthens emergency management practices but also fosters trust, inclusivity, and innovation, ultimately reducing the impacts of emergencies on people, the economy, and the environment.

NEMA established its first science advisory panel for volcanoes in 2012. Since 2022, NEMA has accelerated its efforts to formalise and systematise science advice within the emergency management system, establishing panels for earthquakes, severe weather, and space weather, with a tsunami panel currently under development. These panels are designed to formalise and enhance the delivery of coordinated, high-quality, timely, and authoritative science advice across the 4Rs, with a particular operational emphasis on acute readiness and response.

Rather than duplicating the work of operational science agencies, the panels expand the breadth and depth of scientific expertise available. They include behavioural scientists, Te Ao Māori experts, members of professional societies, university academics, and scientists from MetService, GeoNet, and Earth Sciences NZ, among others. Functioning as a 'network of networks,' the panels foster collaboration across disciplines and institutions to support effective decision-making during natural hazard-related emergencies and disasters.

The panels operate on a voluntary, best-endeavours basis. During emergency events, their advice is channelled to the National Controller and the Director of Civil Defence Emergency Management via the Science Desk at the National Crisis Management Centre (NCMC), enhancing situational awareness and evidence-based decision-making.

This presentation will outline the purpose and operational context of these panels, share early operational experiences, and highlight their contributions to building a resilient and scientifically informed emergency management system for Aotearoa New Zealand.

M8.8 Kamchatka tsunami response ushers in the next generation of Time-Dependent Tsunami Early Warning (TiDeTEW)

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The M8.8 Kamchatka earthquake of July 29, 2025, highlighted inadequacies in the global tsunami early warning system. The system is largely predicated on using earthquake parameters as a proxy for tsunami generation and failed to rapidly determine the tsunamigenic potential of the earthquake for several hours. Initial magnitude estimates from global authorities grossly underestimated the size (M8.0) and tsunami threat of the event. Final operational magnitude estimates (M8.8) led to over forecasting across much of the Pacific.

Aotearoa New Zealand, through the RCET Programme, has recently implemented the operational ability to use direct observations of propagating tsunamis measured by deep-ocean DART buoys to model the tsunami source and forecast tsunami threat. By bypassing the need for estimating tsunami generation from the early earthquake metadata (e.g. magnitude, rupture scaling and slip), tsunami forecasting uncertainties are drastically reduced. Improved forecasting accuracy opens the door to forecasting the evolution of the threat.

Inversion of DART data proximal to the source provided a robust tsunami source model within about 70 minutes of the earthquake origin. Confirmation and improvement of the source model over the next several hours gave us confidence in the accuracy of forecasts based on the source model and led us to generate a time-dependent forecast that accurately predicted the evolution of the threat over the first 48 hours of the event, through to event cancellation about 4 hours before first wave arrival in New Zealand. The forecast captured the hazard posed by secondary arrivals to our eastern shores from wave reflections off South America.

Kamchatka was a critical early and successful “live” test of the RCET TiDeTEW paradigm. Current work is aimed at improvements under the hood in the TiDeTEW generation as well as developing regional forecasting to add to the current national TiDeTEW capability.

S-wave splitting analysis with frequency dependence in Northeastern Japan

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We determine frequency-dependent shear-wave splitting (SWS) in northeastern Japan to examine potential temporal and spatial anisotropy variations in the region. SWS is a phenomenon in which S-waves separate in an anisotropic medium as two shear waves with different velocities and orthogonal oscillation directions to each other. In the upper crust, SWS is mainly caused by stress-induced anisotropy, and the oscillation direction of the fast wave is detected in parallel to the SHmax (Maximum horizontal compression axis) direction. However, in the vicinity of fault zones or volcanoes, anisotropy may be observed in a different direction from the regional compression axis and is assumed to reflect fault-parallel fractures, local stress fields, or upwelling fluid paths (Boness & Zoback, 2006; Johnson et al., 2011).

One advantage of S-wave splitting for analyzing stress fields and crustal structures is its high temporal resolution. In addition, the S-wave splitting parameters show a frequency dependence caused by the width of microfractures or the size of the anisotropic medium in the crust.
In this analysis, we used seismic waveform data based on the JMA (Japan Meteorological Agency) unified catalog, and measured SWS parameters using MFAST (Multiple Filter Automatic Splitting Technique, Savage et al., 2010) and the waveform cross-correlation method. We investigate the frequency dependence by modifying the filters and extending the time windows appropriately.
The Tohoku region and the eastern part of Hokkaido in Japan are areas where anisotropy caused by the SHmax of the subduction zone, inland faults, and volcanoes are commonly observed. Preliminary results show that considering frequency dependence may help separate the causes and detect temporal changes. Through SWS analysis incorporating frequency dependence, we identify temporal variations in anisotropy, suggesting stress release and the formation of fault fractures induced by seismic activity.

As clear as mud: PIV measurements of velocity profiles in small-scale debris flow experiments.

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Debris flows are complex, naturally occurring phenomena involving the mass movement of sediment-water mixtures. Their variable, non-Newtonian rheological properties occur across a range of flows from dilute hyper concentrated flows to dense debris flows. A wide variation in rheological behaviours is thought to occur and to be governed by the interaction of solid and fluid phases, and by the interaction of flows with flow boundaries. Vertical and cross-stream velocity profiles inside flows are causally related to their poorly understood internal stress tensors, and thus to their flow and hazard behaviours. However, capturing such profiles during natural events remains a challenge due to their highly destructive nature.

Small-scale experiments offer a useful analogue to systematically study the dynamics of debris flows under controlled conditions. In this study, we present the first application of Particle Image Velocimetry (PIV) to investigate the vertical velocity distribution of small-scale debris flow analogues. A series of sediment-water flow experiments was conducted using a flume with a transparent wall, and natural grain sediments of varying grain sizes and particles solids concentrations. High-speed imaging was used to resolve the velocity fields across vertical sections of the flow.

To date, PIV work has mainly been applied to synthetic materials such as glass beads, because natural debris flow materials are too opaque for conventional imaging techniques. This work explores the feasibility of adapting imaging techniques for use with natural, poly-disperse materials.
These PIV techniques and insights from these small-scale experiments will be used to inform the design of a new large-scale debris flow facility. By scaling up and integrating techniques employed in this study, we aim to capture vertical flow structures of debris flow under dynamically scaled conditions. This transition will support the refinement of debris flow rheological models and enhance hazard prediction capabilities in vulnerable landscapes.

Dynamics of heat transfer within large igneous province sill complexes

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Large igneous provinces (LIPs) are massive areas of predominantly mafic magmatism, often 10^5 -10^7 km^2 in area with volumes greater than 10^5 km^3, emplaced over a short period (1-5 m.y.). Field studies examining heat transfer processes acting within LIP sill complexes are relatively rare, despite the potential for contribution towards understanding LIP emplacement dynamics and overall interconnectivity of intrusive magmatic systems. This study uses paleomagnetic techniques (alternating field (AF) and thermal demagnetisation) to assess the magnitude of heat transfer associated with LIP sill complexes through the application of the baked contact test. Sampling was carried out through 3000 m of stratigraphy across four sites within the McMurdo Dry Valleys, South Victoria Land, Antarctica, in which 200 m thick Ferrar dolerite sills intrude the Beacon Supergroup sedimentary sequence. Our results will quantify the vertical extent of magmatic heating from the Ferrar LIP sill complex, with implications for understanding magma and heat fluxes during sill complex emplacement and the potential for these systems to liberate extinction-level volumes of crustal carbon.

Evolution of highly vesicular basaltic pyroclasts during fountaining

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The vesicularity of basaltic pyroclasts varies widely, from fully dense glass to 95–99 vol.% vesicular reticulite. The final vesicularities of basaltic pyroclasts are influenced by a range of processes acting on them prior to, and during, cooling. These process, which include vesiculation and bubble growth, bubble coalescence, collapse, and outgassing, are often difficult to disentangle from the textures in the final products. In this study, we analyse highly vesicular pyroclasts that have preserved evidence of these processes, and which fall between typical scoria and reticulite in the continuum of basaltic pyroclasts. The 2021 Fagradalsfjall eruption produced highly vesicular (75-88 vol.%) pyroclasts which can be separated into two different groups based on temporal and textural variations: texturally simple pyroclasts, likely erupted in late-May, are characterised by primarily sub-spherical, large vesicles and a low crystallinity (<5%); whereas texturally more complex pyroclasts, erupted between early April and early May, are characterised by relatively smaller vesicles, with a large variation in vesicle shapes, from spherical to highly irregular. Interactions between cooling, bubble growth, capillary relaxation and coalescence processes, have altered these pyroclasts while they remained hot in the fountain and have contributed to their final texture. Texturally simple pyroclasts are primarily composed of a stable foam and appear to have undergone relatively little bubble film failure and coalescence prior to cooling. Texturally complex pyroclasts, however, capture the textures of a breakdown in the foam as bubble films failed; we conclude that they represent a more mature stage in the textural evolution of these vesicular pyroclasts. The subsequent retraction and relaxation of the bubble films are clearly preserved in different stages throughout the pyroclasts in this group, providing insight into the breakdown process that is often lost in highly vesicular pyroclasts.

Formation of Pele’s hair by stretching of bubbly magma

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Pele’s hair – long, thin, hair-like strands of volcanic glass – is a common product of explosive basaltic eruptions. It has been proposed that strands of Pele’s hairs are formed when small droplets of lava are deformed by strong jets of magmatic gas, which stretch them into long filaments. However, this mechanism does not explain the common occurrence of ‘hanks’ Pele's hair – bundles of hundreds to thousands of near-identical aligned strands. Here, we demonstrate a new mechanism for the formation of Pele’s hair by the stretching of bubbly lava during eruption. We reproduce Pele’s hair experimentally by pulling apart a foam of molten art glass in a custom-built apparatus employing a pulley mechanism. The molten, bubbly glass solidifies as it cools, replicating behaviour in the natural system which is not captured by isothermal analogues.

As the analogue is stretched, Plateau borders between bubbles are deformed and eventually produce long, thin strands of glass. Samples at high bubble fraction (~90 vol.%) produced long, intertwined strands of glass, as thin as 4 µm in diameter. Samples at low bubble fraction (~20%) produced thin glass ribbons containing tube-vesicles, and occasional hair-like strands. Bubble-free samples instead produced a continuous, thin glass sheet with triangular ridges. These represent the range of textures present across a wide spectrum of deformation that may occur in basaltic pyroclasts of varying vesicularities. These experiments reveal an alternative formation mechanism for Pele’s hair, where they may form during weakly explosive or fountaining eruptions, from bubbly lava fragments that separate as they are erupted, deforming the vesicles and stretching to form long strands of glass that cool almost immediately.

Novel radiocarbon measurements of Patea / Doubtful Sound and Tamatea / Dusky Sound particulate organic carbon reveal knowledge gaps in lateral carbon transport and sequestration

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Globally, fjords are considered “hotspots” for carbon sequestration. The glacially carved steep terrain and high rainfall deposit more organic matter into fjords per unit area than any other ecosystem. New Zealand’s Fiordland region has some of the highest organic carbon burial rates in the world, in part due to heavy rainfall, landslides, and earthquakes. Sediment records demonstrate the importance of Fiordland as a critical carbon sink for New Zealand; however, the dynamic processes controlling sequestration remain less clear.

We are developing a carbon fingerprint map through Patea/Doubtful Sound and Tamatea/Dusky Sound using radiocarbon and biogeochemical analyses to characterise sequestered organic carbon under different depositional conditions. Patea is distinct from Tamatea due to anthropogenic forcing by way of the Manapōuri hydro station which has altered the flow dynamics of the fjord. By tracking carbon along both fjords from source to sink, we gain insight into the processes that drive transport and sequestration of carbon into the sediment.

We have analysed the chemical fingerprint of sequestered carbon in the surface sediment to provide a paradigm of carbon composition under contemporary prevailing conditions along each channel. Additionally, we have examined the carbon fingerprint through two mass wasting event deposits to examine source changes, and resultant chemical compositional changes, during event-driven sedimentation. Characterising the differences in chemical composition of sequestered carbon under modern conventional and event-driven sedimentation regimes supports refinement of the contribution of fjords to the New Zealand carbon budget.

Histories of faulting and the twin threats of seismic and volcanic hazards around Taupō Volcano

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Accurate fault-slip histories are pivotal for constraining the total hazard represented by Taupō Volcanic Zone (TVZ) volcanoes due to the demonstrated coeval nature of explosive eruptions and fault ruptures in this area. Paleoseismic studies through tephra sequences around Ōkataina Volcanic Centre have produced high-resolution fault-slip histories and linked them to Holocene eruptions. However, the extra-caldera fault network north of Taupō volcano (the North Taupō Fault Zone) is comparatively understudied, likely due to the presence of areally extensive products of the ~232 CE Taupō eruption that fill valleys with up to 30 m of ignimbrite, burying fault scarps and obscuring fault-slip histories. To better constrain the relationships between volcanic activity and fault-slip in the North Taupō Fault Zone we have utilized ground penetrating radar (GPR) and paleoseismic trenching to reveal the fault-slip history of the Kaiapo Fault.

Trenching localities were selected on the northern portion of the Kaiapo Fault, where it bifurcates into numerous smaller strands that generate landforms in the Taupō ignimbrite, exhibiting <5 m-high scarps. Because the 232 CE Taupō ignimbrite thickens into paleo-topographic lows, sites on ridgelines and on paleo-topographic highs were preferentially targeted for investigation. Additionally, GPR surveys were used to identify along-strike segments where the Taupō ignimbrite would be thin enough for paleoseismic trenching to reach older deposits and be effective. Deep (~5 m) trenches best captured the tephra stratigraphy offset by the Kaiapo Fault.

Applying this approach to three strands of the Kaiapo Fault has revealed at least seven seismic events since 25.5 ka, illuminating the co-volcanic seismic hazard posed by faults in the North Taupō Fault Zone. Additionally, we can demonstrate that fault rupture preceded and/or occurred concurrently with two Taupō eruptions, demonstrating the twin threat posed from both seismicity and explosive volcanism at Taupō Volcano and posing questions around cause and effect.

Using seismic reflection data analysis to add relevance to undergraduate research projects

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During the 2025 academic year, four 300-level (third-year undergraduate) students at the University of Otago undertook 18-point independent research projects as part of their BSc degrees in Geology using seismic data sets collected for a variety of research or teaching purposes. We present a summary of the projects and highlight the personal learning that can be made with focused projects such as these, as well as the significant contribution to academic research.

The four projects highlighted include: a synthesis of weight-drop seismic data collected during three geophysics field schools to examine a shallow coastal setting north of Dunedin, an interpretation of eight short closely-spaced marine seismic lines at the mouth of Otago Harbour collected during a series of 100-level field trips over the course of a week, the analysis of a set of shallow marine boomer lines collected off the coast of Christchurch to examine Last Glacial Maximum erosion and Holocene infill, and the investigation of polygonal faulting distributions in Paleogene/Neogene sediments within the Rigel 3D seismic survey from the Great South Basin.

These projects introduced the students to seismic processing using the GLOBE Claritas platform and seismic interpretation using S&P’s Kingdom software. The use of relevant data sets and state-of-the-art analysis systems has led to good academic outcomes for the students – and possibly increases the likelihood for retention into postgraduate geophysical studies.

Updates on medium-term earthquake forecasting in New Zealand and beyond

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The Every Earthquake a Precursor According to Scale (EEPAS) model is a statistical forecasting framework based on the observation that seismicity tends to increase within a spatial and temporal window preceding major earthquakes. This phenomenon—termed Precursory Scale Increase (Ψ)—follows empirical scaling relationships between precursor time (Tp), precursor area (Ap), and mainshock magnitude (Mm). Ψ has been identified not only in observed seismic catalogues across diverse tectonic settings, but also in synthetic catalogues generated by physics-based earthquake simulators.

EEPAS applies these scaling relations to every earthquake to estimate the future earthquake occurrence rate density. The model has been calibrated to national, regional, and global catalogues and has undergone international testing, demonstrating skill over forecasting horizons ranging from months to decades.

In New Zealand, EEPAS contributes to the hybrid forecast model developed in response to the Canterbury and Kaikōura earthquake sequences and incorporated into the 2022 revision of the National Seismic Hazard Model. Recent refinements address two key limitations: (1) magnitude-dependent incompleteness of precursory contributions when forecasting across a time-lag, and (2) missing precursory earthquakes prior to the catalogue start date. Two additional features—currently under development—are essential for further improving EEPAS performance: (a) the space-time trade-off in precursory seismicity, and (b) the dependence of precursor time on spatially variable strain rates or long-term earthquake occurrence rates.

We're making the original EEPAS code open-source and rewriting it in Python to make it easier to use and maintain. The goal is to help more people understand the model, encourage collaboration, and improve global earthquake forecasting and resilience.

This poster provides an overview of the EEPAS model, its empirical foundations, recent enhancements, and future directions for integrating these outstanding features into operational forecasting.

Toward a FAIR framework for earthquake catalogues in Aotearoa, New Zealand

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Earthquake catalogues underpin research in seismology, operational monitoring, and risk management. In Aotearoa New Zealand, they are developed for many purposes, leading to uneven accessibility, standardisation, and interoperability. To address these challenges, we convened two community workshops that brought together agencies, researchers, and industry partners to co-design a practical framework guided by the FAIR principles. The current catalogue landscape is diverse. It includes volcano-focused microseismic studies in the Taupō Volcanic Zone and Whakaari, temporary deployments on the Alpine Fault and Hikurangi margin, and national datasets such as the GeoNet catalogue, focal mechanisms, and moment tensors. While these resources offer depth and precision, they also face persistent issues: variable completeness, inconsistent processing, uncertain magnitude and depth scales, missing metadata, opaque methodologies, and limited access to legacy and temporary data. To address these gaps, the working group used ideas from the first workshop to create a prototype portal as a central hub for compiling and, in the future, integrating earthquake catalogues. The portal allows developers and data providers to submit datasets with details on methods, uncertainties, processing history, and persistent identifiers to ensure traceability and reproducibility. The prototype was presented at the second workshop, where it received strong endorsement and constructive feedback, underscoring its potential as a foundational tool for future data-sharing initiatives. The working group is also developing a pipeline that incorporates modern methods to improve catalogue quality, such as template matching, machine learning, and dense seismic arrays, along with recommendations for assessing their added value and ensuring transparency. Here we present the outcomes of both workshops, updates from the working group, and a report outlining metadata standards, a shared parameter lexicon, programmatic access, and governance structures. The framework aims to make earthquake data more transparent, comparable, and reusable, improving reproducibility and supporting better hazard and risk decisions across Aotearoa.

New Zealand heritage stones: geoconservation for Earth Sciences outreach

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The International Union of Geosciences (IUGS) Heritage Stone designation is a valuable tool to promote geological knowledge, usage, and conservation of these culturally, architecturally, and historically significant natural stones. Additionally it provides an excellent basis for outreach activity, raising public awareness about geological heritage and encouraging protection and celebration. In 2025, the Geoconservation Trust Aotearoa Pacific made submissions to the IUGS Heritage Stones Commission for three New Zealand Stones, with the submissions currently under review. Geoheritage in New Zealand is a still evolving discipline, and mainly site specific, rather than applied to the broader significance of stone types in cultural development, architecture, and community awareness of geological materials. Emphasizing the relevance of heritage stones in New Zealand, we aim to enhance geoconservation and facilitate engagement with New Zealand's geoheritage through science, education, art, tourism, and community development.

The three stones we selected for consideration are Hinuera Natural Stone (a welded ignimbrite of the Taupō Volcanic Field), Coromandel Granite (an important tonolite similar in appearance to granite that was valuable at a time before imported stones became readily available), and the perhaps surprising inclusion of New Zealand Greywacke.

In New Zealand, greywacke denotes a well-defined suite of metasedimentary rocks that constitute approximately one quarter of the nation's most distinctive and iconic landscapes and geographical features. Although it has a widespread national presence, the geoheritage value of greywacke has often been overlooked. Greywacke has played an important role in New Zealand communities from pre-European Māori society to modern-day industrialized society. Additionally, this rock holds the story of terrane accretion on the eastern continental margins of the Gondwana supercontinent, hundreds of millions of years ago. Subsequent rifting formed the mostly underwater continent of Zealandia, where unimaginable and relentless tectonic forces have brought our geological basement to the surface.

Applications and future potential of borehole image logs in New Zealand's subsurface characterisation

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Borehole images offer high-resolution insights into subsurface geology, capturing lithology, fractures, faults and in-situ stress conditions in the Earth's subsurface. These data are critical for understanding permeability and fluid flow within a regional tectonic framework. In New Zealand, acoustic borehole images – using ultrasonic scanning tools - are more commonly used than resistivity or optical images, mainly due to availability of the tools. These images provide continuous and direct measurements of fracture orientation, density, and thickness, and are most effective when integrated with outcrop data, core samples, and other geophysical datasets.

In New Zealand, borehole images have been run for geotechnical, geothermal and hydrocarbon purposes. In geotechnical studies, they help understanding how hillslopes will perform in future earthquakes and significant rainfall events. In geothermal studies, fractures and in-situ stress results combined with independent permeability assessment clarifies the characteristics of fractures bringing hot fluids. When used in several nearby boreholes, results help refining the 3D geological models to better understand the geothermal reservoir. In petroleum boreholes, borehole images aided structural and sedimentological interpretations of the boreholes and surrounding areas. Looking ahead, borehole imaging holds promise for evaluating subsurface reservoirs for alternative uses, including hydrogen storage, carbon sequestration, and mineral exploration. We highlight the versatility and evolving role of borehole image logs in subsurface characterisation across diverse geological settings.

An inside look at the GeoNet products and services architecture

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GeoNet is Aotearoa New Zealand's national land and geohazards data and monitoring system. Its data pipeline is made of physical and virtual infrastructure, systems and practices that enable data collection, dissemination and custodianship. Monitoring functions and GeoNet data users are all dependent on these core functions and infrastructure.

To accommodate the diversity of data types, products, tools and services, and to meet evolving user needs, the GeoNet system architecture has evolved in time, and has been built with different resilience levels. Over the past decade, the GeoNet infrastructure has been slowly but steadily migrated to the cloud. The transition is still ongoing and presents new challenges and learnings as volumes of data requested rise.

The GeoNet system architecture is a complex web of services that deliver many TB of data every year to users around the world in near real time data feeds. In this presentation, we offer a behind-the-scenes look at this intricate system, highlighting key architectural solutions, the challenges of maintaining and scaling them, and the ongoing efforts to ensure high availability, cost efficiency and agility of the GeoNet data infrastructure.

Evaluating the effect of the 1942 Wairarapa earthquake sequence on landslides using aerial imagery

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Widespread slope failures occurred across the lower North Island, New Zealand during the 1942 Wairarapa earthquake sequence, affecting an area of approximately 6,500 km2. Two main events on June 24 (MW 7.2) and August 1 (MW 6.8) generated shaking intensities up to MM8, causing moderate to severe damage in the Wairarapa, Manawatu, and Wellington regions. Due to the absence of surface rupture and limited instrumentation networks, the distribution of coseismic landslides serves as an important proxy for subsurface faulting and associated ground motions.

In this study, we build pre- (1942) and post-earthquake (1943, 1969) high-resolution orthomosaics and DEMs from historic aerial photographs to map landslides triggered by the 1942 earthquake sequence. We mapped landslides in a 61.3 km2 area where pre- and post-earthquake imagery overlapped, allowing us to assess their relative ages and attribute likely triggers. Landslides mapped in pre-earthquake imagery are interpreted as rainfall-induced, while those mapped from post-earthquake imagery are interpreted as earthquake-induced. Additional landslide characteristics including lithology and failure style, as well as their spatial distribution are assessed to refine interpretations of triggering conditions.

Preliminary results suggest a high number of landslides predate the first earthquake and were likely triggered by historic weather events in the region. Meteorological records indicate heavy rainfall between the June and August earthquakes, suggesting that reduced slope stability from antecedent conditions may have contributed to some slope failures. This raises uncertainty over whether certain post-earthquake landslides were triggered by shaking or rainfall acting on weakened slopes.

These results highlight the challenges of confidently assigning landslide triggers in multi-hazard settings. By attributing seismic and climatic triggers, this study enhances the accuracy of historic landslide inventories and provides critical data for improving regional landslide susceptibility models and seismic hazard assessments across regions where seismic and climatic triggers interact.

A descriptive catalogue of earthquakes in Aotearoa New Zealand from historical written sources, 1840 to 1870

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Past earthquakes provide an important guide to future seismic hazards. In Aotearoa New Zealand, the reliable instrumental record of earthquakes only dates back to the 1940s, limiting our understanding of the range of possible earthquakes and the time between them. The addition of 100 years of seismicity to the existing National Earthquake Information Database (NEID) would allow us to greatly improve our understanding of seismic hazard in Aotearoa New Zealand, yet the potential contributions of historical seismology are often-overlooked since the available data is primarily qualitative. Historical seismology involves collecting archival sources – newspapers, letters, diaries, journals, official felt reports and photographs – to determine the seismic intensities observed in historical earthquakes.

Previous research by George Eiby, Gaye L. Downes, Rodney Grapes and David Dowrick documented in detail felt earthquakes in Aotearoa New Zealand from 1840 to 1854. Eiby intended to catalogue historical seismicity from 1855 to 1870 but this work was never completed. It is thought the NEID is complete to Mw 7.0 since 1840.

In this study, we comprehensively document Aotearoa New Zealand seismicity from 1840 to 1870 using digitised newspapers from across the country. Converting these qualitative accounts into quantitative intensity data allows the mapping of observed shaking caused by earthquakes for which we have no instrumental record. From these intensity data seismic parameters – magnitudes, epicentral locations and depth estimates – can be derived, allowing for previously undocumented earthquakes to be catalogued consistently with instrumentally recorded events.

A catalogue of 420 felt earthquakes between 1840 and 1870 inclusive has been collated. This has increased our current knowledge of seismicity in this period, particularly between 1855 to 1870. This detailed catalogue and the methodologies underpinning its collation will provide a blueprint for future investigations of later poorly studied periods in the 19th and early 20th centuries.

Transoceanic tsunami impact and simulation in New Zealand from the 2025 Kamchatka Mw 8.8 earthquake

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The Kamchatka subduction zone hosted some of the largest recorded earthquakes in the world. In 1952, an earthquake with Mw 8.8-9.0 occurred offshore Kamchatka peninsula and generated a tsunami. Fast forward 73 years, another massive Mw8.8 earthquake struck the same region on 29 July 2025 at 23:24 UTC. The 2025 earthquake generated a tsunami with a maximum runup of 18 m recorded in Vistnik Bay, Kamchatka, Russia. Offshore Kamchatka, the highest deep-water tsunami amplitude of 77 cm was recorded by DART buoy 21416 station. The tsunami propagated across the Pacific Ocean, triggering warnings in New Zealand where forecasts predicted waves exceeding 30 cm. These predictions utilized precomputed models, and a tool called TL Mapper to assess threats across all 43 national warning zones in real time. We also simulated the tsunami using the finite fault model estimated by the USGS. The geometry of the fault model has a strike 218° of and dip of 20°. The average rake angle of the model is almost perpendicular to the trench, and the maximum slip amount is 14 m. In this study we evaluate the earthquake source model using the tsunami waveforms recorded at offshore DART buoys and coastal tsunami gauges. The tsunami caused sea level oscillations capable of causing strong and unpredicted currents for more than two days, this phenomenon was clearly shown by water level observations at the Chatham Islands. The tsunami records also show the tsunami reflected from South America. The simulation result can also be used to evaluate the effectiveness of the RCET TiDeTEW (Time Dependent Tsunami Early Warning), that produced time dependent threat level maps in real time. This evaluation is useful to improve the tsunami warning de-escalation procedure.

Can data from IODP Expedition 405 to the Japan Trench explain a correlation between low flexural rigidity and slip during the 2011 Mw9.1 Tōhoku-oki earthquake?

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Flexural rigidity, a measure of lithospheric strength in response to loading, mapped along the Japan Trench exhibits an intriguing correlation with slip extent during the 2011 Mw 9.1 Tōhoku-oki earthquake – the slip occurred almost entirely within a region of low flexural rigidity that includes the forearc, the trench and the near-trench parts of the incoming Pacific plate. This relationship also holds for slip during all but one instrumentally recorded giant (M>9) earthquake, leading to the hypothesis that subduction zone flexural rigidity is a proxy for maximum likely lateral rupture extent during giant earthquakes. Confirming this hypothesis requires an explanation for this apparent correlation, but such an explanation remains elusive.

Physical property and structural data from cores and logging-while-drilling data acquired in late 2024 during International Ocean Discovery Program Expedition 405 may help to explain the observed correlation between low flexural rigidity and co-seismic slip. This expedition drilled multiple boreholes at two sites landward and seaward of the Japan Trench to investigate the conditions and processes that facilitated extremely large shallow slip on the subduction interface during the Tōhoku-oki earthquake.

Structural measurements from accretionary wedge sediment cores constrain the deformation accommodated above the principal slip zone, which may be linked to flexural rigidity. Drilling results also constrain whether a weak pelagic clay layer, variably present in sediments covering the incoming Pacific Plate, persists within the plate boundary fault zone. Bend faulting, which would weaken the incoming plate, is pervasive along the Japan Trench and surprisingly not limited to the region of low flexural rigidity and high slip.

Whilst no giant earthquakes have been recorded instrumentally on New Zealand's Hikurangi subduction margin, variations in flexural rigidity along this margin are similar to those along the Japan Trench. These variations may, therefore, be an indicator of possible future rupture extent and tsunamigenesis.

A new subaerial record of explosive volcanism and associated tsunami deposits on Tongatapu Island, Tonga

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Despite frequent volcanic activity, the eruption history of the Tonga Volcanic Arc remains poorly constrained due to the small landmass of the Tongan archipelago (~750 km²) and limited Holocene subaerial exposures. To address this, we apply tephrochronological methods to swamp cores from Tongatapu Island, east of the volcanic front and downwind of high-altitude winds. These closed lacustrine and swamp environments, formed in lagoon basins isolated after the mid-Holocene high sea level stand, preserve tephra layers more effectively than surrounding tropical soils. Thus, it provides an untapped archive of past explosive eruptions and tsunami events.

Coring reveals multiple tephra layers within humic sediment and peat, with radiocarbon dating establishing an eruption timeline over the past ~6500 years. Glass geochemistry indicates basaltic andesite to dacite compositions (57-69 wt.% SiO_2), with most layers resembling the major element chemistry and mingled textures of the 2022 Hunga eruption. Significant events from Hunga Volcano are identified at AD 418-645 and AD 1119-1279.

At an archaeological midden site in Talasiu, we document a ~15 cm marine deposit containing large, clean corals and shells, sharply overlain by >5 cm of dark grey Hunga-derived tephra (dated ~AD 500). The deposit's abrupt contact with underlying clay loam and absence of matrix suggest tsunami emplacement, with thicknesses indicating a more substantial event than 2022. This layer correlates with another tephra from the island's opposite side, indicating widespread ash fallout. We interpret this as evidence for a major, likely submarine, Hunga eruption around AD 500 that generated a tsunami impacting the inhabited Tongatapu Island.

This work refines the eruption chronology of the Tonga Volcanic Arc, strengthens volcanic-tsunami event correlations, and underscores substantial hazard potential from Hunga Volcano, particularly on Tongatapu Island, where >70% of Tonga's population resides. Ongoing analyses extend tephrochronological correlations across other Tongan island groups to improve regional geohazard assessment.

DEVORA outreach: connecting science and society to strengthen Auckland's volcanic readiness

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The Determining Volcanic Risk in Auckland (DEVORA) research programme was launched in 2008 to address the unique challenges of distributed volcanism in an urban setting. Jointly led by the University of Auckland and Earth Sciences New Zealand and funded by the Natural Hazards Commission and Auckland Council, DEVORA investigates the hazards and risks associated with the potentially active Auckland Volcanic Field (AVF). A key component of DEVORA's mission is public education and outreach, so our diverse society trusts and understands our science and knows how to respond appropriately during volcanic events, especially given the uncertainty of when, where, and how the next AVF eruption might occur.

In 2014, due to growing demand, DEVORA created an outreach group, led by a dedicated Outreach Coordinator since 2018. A multi-pronged outreach strategy guides prioritisation of active engagements, such as school visits, science festivals, field trips, and community talks, and for utilising passive engagement tools, such as fact sheets, exhibits, social media, and a website, all free to requestors. To maximise impact with limited resources, DEVORA prioritises free events with underserved communities, large audiences, and low-decile schools. More than 95 public engagements have been delivered to date, with social media content reaching >130,000 people. A Communications Plan and Media Guide support media interactions and promote open-access publishing. Our research has featured in ~200 media stories, further amplifying reach. Through stable funding and ongoing presence, DEVORA also supports nation-wide efforts like EarthFest, House of Science, and other hazard groups.

Our experiences highlight the importance of a consistently funded and clearly defined outreach strategy from the onset of a scientific programme. Maintaining strong partner relationships with emergency management and timely communication during high-profile eruptions worldwide also enhances public engagement. DEVORA's long-term outreach commitment continues to strengthen community resilience in one of Aotearoa's most at-risk urban areas.

The occurrence and morphology of naturally occurring respirable mordenite mineral fibres in New Zealand

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Mordenite is a naturally occurring zeolite mineral that is the sixth most common zeolite mineral globally, forming at low temperatures (<40 °C) in hydrothermal systems. In New Zealand, extensive deposits of mordenite are commonly associated with areas of hydrothermal alteration, particularly in the Coromandel and Taupo Volcanic Zones, where several industries have the potential to disturb these naturally occurring mineral fibres, causing them to become aerosolised and potentially respirable. Naturally occurring mordenite is a fibrous mineral that is not known to be carcinogenic, in contrast to the fibrous zeolite, erionite. Indeed, erionite is a Group 1 carcinogen that has been linked to malignant mesothelioma due to its fibrous-asbestiform shape and biodurability. In this study, mordenite from New Zealand is characterised and compared to erionite, using X-ray Powder Diffraction (XRPD), Scanning Electron Microscopy–Energy Dispersive Spectroscopy (SEM-EDS), and an Automated Scanning Electron Microscope (SEM) in order to understand the extent, occurrence and morphology of mordenite in New Zealand. It also allowed the evaluation of potential health implications, including whether these naturally occurring mineral fibres are respirable.

Source to sink sediment analysis in the upper Whakaraupō | Lyttelton Harbour

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Following European arrival in New Zealand, erosion and sedimentation rates in the upper Whakaraupō | Lyttelton Harbour have risen over the historical baselevels. Past research has shown that land-use change has increased exposure of highly erosive, loess-derived soils across Banks Peninsula, with raised sedimentation rates impacting local marine ecosystems to the concern of the local hapu (Te Hapu o Ngāti Wheke) and local communities.

While considerable work to understand the erosional processes and environmental impact across Whakaraupō has occurred, the head of the harbour lacks a high-resolution analysis of erosion and sedimentation rates.

To quantify the sedimentation rates in the Head of the Bay and Charteris Bay catchments, source to sink sedimentary analysis of marine and terrestrial samples has been undertaken. Grain size distribution was assessed through sieving and laser sizer analysis. Portable X-ray fluorescence will be used for geochemical assessment. Erosion modelling, using the Integrated Valuation of Ecosystem Services and Trade-offs (InVEST) software, will identify erosion hotspots and erosion rates across the catchment. Inputs include grainsize, land use, rainfall, topographical data.

Initial results from 71 marine samples indicate grains between 2 and 125um represent >69% of the marine sediment, with silt and very fine sand most prominent. Findings from Evans (2023) and Thwaites (2023) suggest this correlates mostly with fine grainsizes found in local loess deposits. The next steps are to geochemically fingerprint the variability of in-situ loess and volcanic units to trace the provenance of marine sediment, including differentiating possible sediment sources outside of the harbour.

By tracing sediment sources and identifying erosion hotspots in the Head of the Bay and Charteris Bay catchments, this research builds upon previous studies and provides insight for local environmental managers, including the Whaka-Ora Healthy Harbour Trust, by helping to inform future erosion mitigation strategies and slow sedimentation into the marine environment.

Do multi-GNSS solutions impact the results of the final product? Moving from a GPS only, to multi-GNSS solution

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Global Navigation Satellite Systems (GNSS) provide a robust framework for determining and monitoring precise locations on Earth's surface, forming the backbone of the reference frame underpinning modern New Zealand datums. Historically, this framework has relied predominantly on the GPS constellation. Advances in product offerings and processing techniques have enabled the adoption of multi-GNSS approaches.

Multi-GNSS solutions incorporate signals from GPS, GLONASS, Galileo, and other constellations to enhance positioning outcomes. By increasing the number of observations, the quality of the final product is improved through increased satellite visibility, improved redundancy, reliability and enhanced accuracy through error mitigation.

To evaluate the effectiveness of these enhanced processing methods, a series of tests were conducted comparing different GNSS solution types across multiple continuously operating reference station (CORS) networks. Integrating CORS sites established for a variety of purposes with the national PositioNZ network expanded spatial coverage and sample size, allowing for more comprehensive testing of solution parameters.

Surveying professionals across New Zealand are increasingly adopting multi-GNSS solutions within their private networks. This initiative aims to align national GNSS products with internationally agreed future state set by IGS (International GNSS Service), ensuring consistency and interoperability. The outcomes of these tests aim to inform the planning framework for future updates to New Zealand's geodetic reference frame, supporting its continued accuracy and resilience in a multi-GNSS environment.

Co-erupted plutonic enclaves in dacitic magma at Belfond Volcano, Saint Lucia, Lesser Antilles Arc, from an amphibole and plagioclase perspective

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Texturally and compositionally distinct types of amphibole and plagioclase phenocrysts in dacite lava and plutonic enclaves co-erupted at 13.6 ka from Belfond Volcano, Lesser Antilles Arc, provide insight to how the subterranean plumbing developed. Three textural types of amphibole and plagioclase are present in the enclaves, while the host dacite contains cummingtonite and two types of plagioclase. Equilibrium melt compositions determined from amphiboles are mostly rhyolitic. The cores of the amphibole phenocrysts are consistent with nucleation in a less silicic melt, while rhyolitic melt compositions are estimated from outer-rim zones. Ca/Na ratios of plagioclase show that the sodic domains grew in a rhyolitic melt, while the calcic domains nucleated in a melt more calcic (and mafic) than the magmas erupted at Belfond. Melts modelled from Mg in plagioclase indicate that the phenocrysts re-equilibrated in a rhyolitic melt with a MgO content of ~0.2 – 0.5 wt% and were stored at elevated magmatic temperatures. Pressure and temperature conditions based on amphibole indicate two staging depths within the crust – a shallower system at ~5 km (~140 MPa) and temperature of ~800°C; and a deeper system at ~15 km (~400 MPa) and temperature of ~900°C. The shallower system correlates with more silicic melts estimated from amphibole, while the deeper system correlates with more mafic melts. Phenocryst zoning patterns suggest that most amphibole and plagioclase phenocrysts nucleated in the mafic melt of the deeper system and later grew in the silicic melt in the shallower system. Cummingtonite originated in a hydrous and low-pressure zone of the magmatic system, indicating a separate magmatic evolution. This broadly aligns with previous models based on zircon chronology indicating prolonged storage. However, although the enclaves and dacite are co-magmatic, they evolved along distinct pathways.

Shallow magma intrusion processes in the Auckland Volcanic Field

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Natural erosion, drillholes and quarrying have revealed evidence for various kinds of shallow magma intrusion into soft Quaternary sediment associated with eruptions of four Auckland volcanoes. At Te Motu a Hiaroa/Puketutu there is a 400 m-long narrow sill with a crestal dike and deep baking of the overlying sediment. At Pupuke, blocks (up to 4 m-across) of baked rhyolitic sediment (porcellanite) have been baked as they were rafted along in the top of a flow exposed in Smales Quarry. They were likely ripped off the shallow in-situ Pleistocene sequence by intrusive tongues of magma. At Maungarei/Mt Wellington a large (25 m long x 8 m thick) block of baked Pleistocene sediment and overlying section of tuff ring has been transported 500 m within a 30 m-thick flow seen in a quarry wall. This rafted block appears to have been undercut by a sill intruding along the Pleistocene-Waitemata Group contact, lifted off and incorporated it into the voluminous lava outpouring. Along the southern shore of Rangitoto there are blocks of red-baked Holocene and unbaked Pleistocene sediment within some of the younger basalt flows. The Holocene blocks are inferred to have been sourced from the walls of the magma conduit as it approached the surface and been baked within the hot flows as they were transported 4 km to the coast. The unbaked Pleistocene blocks appear to have been intruded by the advancing toes of cool lava flows as they ploughed into the seafloor sediment. The blocks have been carried up to the surface within the basalt lava. These examples demonstrate the diversity of shallow intrusive–extrusive interactions in the Auckland Volcanic Field and highlight the role of magma–sediment processes in generating rafted and baked blocks during eruption.

Magnetotelluric measurements in the Marlborough Fault Zone

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In the north-eastern South Island, the Hikurangi subduction zone changes to strike-slip in the Marlborough Fault System (MFS) which consists of the four main faults, Wairau, Awatere, Clarence and Hope fault. Previous 2-D inversion modelling from a profile of magnetotelluric measurements across the MFS made prior to the Kaikōura earthquake, imaged conductors below the shallow seismogenic zone beneath the main faults. These conductors were interpreted to be interconnected fluid within ductile-shear zones. To test the 2-D model and to better understand the distribution of ductile shear beneath the MFS and its relation how strain is partitioned in 3-D, an MT survey of the northern part of the South Island, is underway. MT measurements will be done each year during the annual scheduled maintenance of the high voltage DC transmission line that runs through Awatere Valley and is a major source of non-plane wave electromagnetic noise. Preliminary 3-D inversions of the MT data collected during the 2024 and 2025 measurement campaigns will be presented.

GeoNet's geohazard monitoring data in the cloud: how to find and use them?

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The GeoNet programme, hosted by Earth Sciences New Zealand, is the country's leading land and geohazard monitoring system. It collects and disseminates data related to earthquakes, tsunami, volcanic activity, and landslides through a range of public channels.

Alongside more traditional data distribution channels, the GeoNet data archive is publicly available through the free Amazon Web Services (AWS) Open Data Program via an S3 cloud storage service (s3://geonet-open-data). This repository contains seismic waveforms, camera images, geodetic, coastal-gauge, and geomagnetic data, as well as generic time series that include volcano and landslide monitoring datasets, amounting to almost 100 terabytes of data.

The open data bucket is designed to support big data research and enable cloud computing, while allowing GeoNet to provide a cost-effective data dissemination service - especially valuable approach in the context of declining funding.

We will showcase tools for interacting with the GeoNet open data bucket, including an ObsPy plugin for retrieving seismic waveforms and event metadata, and Jupyter Notebooks that use the AWS Boto3 library to access and analyse data directly from the bucket.

These tools empower researchers, developers, and analysts to efficiently explore and utilise New Zealand's geohazard data in scalable, cloud-native workflows.

GeoNet seismic benchmark dataset for AI-driven seismology in New Zealand

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Artificial intelligence (AI) is revolutionising seismology, enabling rapid advances in earthquake detection, seismic phase picking, early warning systems, subsurface imaging, and hazard assessment. These innovations are powered by access to large, high-quality, labelled benchmark datasets that allow AI models to be trained with accuracy and reliability.

Globally, benchmark seismic waveform datasets have played a pivotal role in the success of AI applications. However, New Zealand's unique tectonic setting along the Pacific-Australian plate boundary - characterised by complex subduction zones and a transform fault - requires region-specific datasets to ensure model relevance and performance.

To address this need, the GeoNet programme, hosted by Earth Sciences New Zealand, has produced the GeoNet Seismic Benchmark Dataset. This dataset is curated from the publicly accessible GeoNet earthquake catalogue and seismic waveform data. It contains ~2.7M 3-component event waveforms and ~150K 3-component noise waveforms with associated metadata in HDF5 format. Standalone metadata is available in CSV format to support a wide range of AI applications. It is openly available via the Amazon Web Services Open Data programme to support the training and evaluation of AI models tailored to New Zealand's seismic environment even in the cloud.

This initiative will accelerate AI research in seismology, foster collaboration across research institutions and government agencies, and enhance New Zealand's geohazard resilience. By leveraging cloud-native infrastructure and open data principles, the GeoNet Seismic Benchmark Dataset aims to empower scalable, reproducible, and impactful AI applications for the future of seismic monitoring in New Zealand.

Heed the taniwha

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Pūrākau are a traditional expression of mātauranga Māori, in narrative form, comprising philosophical thought, epistemological constructs, cultural codes and world views. Pūrākau are an integral part of mātauranga Māori. They include explanations of landscapes, seascapes and associated phenomena, consistent with a Māori world view, deliberately constructed to encapsulate and condense into easily understood forms, Māori views of the world, of ultimate reality and the relationship between the atua (deities), the universe and humans. Pūrākau explained as 'myths' invalidate Māori ontological and epistemological constructs of the world, and pūrākau understood as just 'stories' is an inadequate explanation of the importance and efficacy of pūrākau in teaching, learning and the intergenerational transfer of knowledge.

Could the science of storytelling be directly linked to the art of survival? Taniwha are a form of pūrākau, that can have varied meanings to different whānau (families), hapū (groups of families) and iwi (tribal nations). One common widespread understanding is that taniwha are our kaitiaki – our guardians. However in contemporary New Zealand society, taniwha, and those who know and speak of them, are at best widely misunderstood, at worst ridiculed. Practically, taniwha serve to reduce disaster risk, acting simultaneously as warning signs and guardians. This talk will discuss taniwha and their role in contemporary Aotearoa New Zealand, their emergent intercultural use in decision-making, and how they continue to keep us safe.

Tāmaki herenga waka, Tāmaki herenga tangata, Tāmaki makaurau – what stories sit behind names?

Robbie Paora[1]
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Tāmaki herenga waka – Tāmaki the converging place of many canoes.
Tāmaki herenga tangata – Tāmaki the converging place of many peoples.
Tāmaki Makaurau – Tāmaki loved by many.

These names are examples of Māori views of and relationships with te taiao – poetic, metaphorical, grounded in experience of place, and explaining natural phenomenon. Hochstetter's exquisite 1859 map depicting the Auckland Volcanic Field is widely regarded as a product of the first comprehensive geologic survey of the area. We are indebted to Hochstetter and the cartographers for this 'snapshot' in time, with its glorious detail, and for providing a record of the features before a city rode roughshod over it – many are significantly modified, some lost forever. What is equally notable is the inclusion of a great many Māori place names in the map, comprising the overwhelming majority. Those names, and the wider mātauranga Māori they draw from, are immediately apparent and present, but effectively silent.

In this presentation we will hear some Ngāti Whātua kōrero regarding some volcanic features in the Auckland Volcanic Field, the stories behind the names.

Rupture models of past large Alpine fault (New Zealand) earthquakes to inform imminent seismic hazard

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As part of the Southern Alps Long Skinny Array (SALSA) project, ~53+ seismometers have been deployed with 10–12 km spacing along a 450 km-long section of the Alpine Fault. The SALSA array focuses on determining the ground motions likely to be produced by a future Alpine Fault earthquake. To achieve this we need to first better determine the Alpine Fault's subsurface geometry, present-day slip rates, and spatial variations in how tectonic stresses are currently accumulating on the fault. We also need to synthesise long-period Green's functions representing accurate path effects between sources distributed along the fault and population centers throughout the South Island. This collective understanding of rupture behavior and path effects allows robust modelling of the ground shaking that would be recorded at key locations throughout central and southern New Zealand. We will present ground shaking hazard resulting from a comprehensive range of geophysically and geologically informed earthquake rupture scenarios and empirically derived location-specific Green's functions. Our research shows the influence of inferred Alpine Fault source models as well as current knowledge of the fault geological and geophysical parameters on regional seimic hazard applications.

Synchronous antiphase rainfall patterns in the tropical South Pacific during the Last Glacial Period: evidence from the speleothem paleoclimate record

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Northern and Southern Hemisphere ice cores show that unlike the Holocene, the Last Glacial Period was a time of global climate instability. In the Northern Hemisphere, this instability manifests as periods of rapid warming of up to 10oC from a cold background state followed by a longer period of cooling. Climate modelling suggests that rapid warming in the Northern Hemisphere is associated with disruptions in global ocean and atmospheric circulation. These disruptions may manifest in the tropical South Pacific as a change in the position and extent of the South Pacific Convergence Zone (SPCZ). The SPCZ is a zone of intense atmospheric convection and rainfall, and modern climate records show that it responds to seasonal and interannual climate variations by migrating as a continuous linear feature.

The SPCZ is the primary source of fresh water for the island nations of the Pacific, and also influences the location, frequency and trajectory of tropical cyclones. Tropical cyclones can have devastating impacts on small island nations and significant impacts on the larger nations of the South Pacific. Any persistent changes in rainfall and tropical cyclone patterns will have major implications for the long-term viability of many Pacific nations.

Speleothems are known as the ice cores of the tropics because of their ability to preserve high-resolution climate records over long time periods. Here we present a series of coeval speleothem records for the Last Glacial Period from Niue, the Cook Islands and French Polynesia. These new records reveal changes in rainfall that are synchronous with rapid warming in the Northern Hemisphere, and these changes can persist for hundreds to thousands of years. The new records also show more complex changes in rainfall across the pacific than would be suggested by modern climate records.

Multiple approaches toward earthquake shaking prediction: application to a Wellington building

Caroline Holden[1], Quincy Ma[2], Tessa Beetham[3], Cain Stratford[3], Harry Gawne[4], Theo Rivet[3]
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Resilience to seismic hazard in New Zealand (NZ) relies on better understanding and quantifying earthquake impact on building performance. The acceleration response of a building is influenced by the earthquake characteristics as well as that of its own structural characteristics and secondary components. More specifically the extent of non-structural damage caused by the 2013 M6.6 Cook Strait and 2016 M7.8 Kaikōura earthquakes highlighted the importance of gaining a better understanding of the seismic demands imposed on the parts and components of buildings.

In this study we compare and quantify the floor performance of one of the buildings at Te Puni Village (instrumented by GeoNet) using four NZ specific approaches listed as follow:

- NZS1170.5:2004 Section 8: Parts and Components (the current National loadings Standard),
- The recommended mode-based approach by Haymes et al. (2023),
- Floor amplifications obtained from an engineering desktop analytical building model,
- And behaviour derived from advanced seismological methods applied to the building seismic array data.

This comprehensive, inclusive and building-specific analysis provides quantitative comparison between the four methods in great detail for a medium height NZ building that has been exposed to moderate to strong levels of shaking. It will help inform building stakeholder and engineering communities in general and future resilient design and assessment procedures in particular.

Chemical time capsules: how we can use molecular fossils as markers of environmental change

Bella Duncan[1,2], Christopher Hollis[1]
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Molecular fossils, or biomarkers, are chemical remnants of past life on earth. Living organisms synthesise molecules that can be deposited in different geological archives when they die. These molecules can be preserved for many millions of years, and some of our records of the earliest life on earth come from molecular fossils. Molecular fossils can be used to reconstruct many aspects of the environment in the past, including what life was present, air and ocean temperatures, depositional histories, human impacts, and how processes like the hydrological and carbon cycles operated. Here, I'll introduce how we can use molecular fossils as environmental proxies, with a focus on how they have been used to address some of the key challenges of our time including climate change, environmental degradation and human impacts on ecosystems.

Nō hea tō whenua – Where is your land from?

Christopher Hollis[1]
[1]Victoria University of Wellington, Carterton, New Zealand

Nō hea koe? Where are you from? That’s a common question amongst Māori, who have a strong sense of place and believe that origins are important. As important then, but perhaps less frequently asked by Tangata Whenua, people of the land, is “nō hea tō whenua”, where is your land from? The question seems obvious if we only consider the young cover rocks that are eroded from the mountains behind us or deposited by the sea in front of us, but for the foundations below, the basement rocks, the answer is much more complex and has deep resonance for the people of the Pacific.

This talk reviews the evidence for the origins of the basement rocks of the lower North Island, comparing the provenance and age of the Gondwanan margin sediments with the information that radiolarian microfossils provide on the age and paleolatitude of the oceanic sedimentary rocks that have migrated from disparate parts of the ancient Pacific ocean before their accretion at the Zealandian edge of eastern Gondwana.

The Gondwanan margin rocks consist of three to four belts that range in age from middle Triassic to middle Cretaceous (Torlesse composite terrane). Associated oceanic rocks within each belt are consistently older by 45 to 20 million years (Permian to early Cretaceous). Based on an average seafloor spreading rate of 100 km/My for the Mesozoic Pacific Ocean, the oceanic rocks originated between 2000 and 4500 km away from the Gondwana margin. Paleobiogeographic affinities with mid-latitude radiolarian assemblages suggest an origin to the east rather than to the north.

Is New Zealand paleontology a dying field?

Christopher Hollis[1]
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Not so long ago, New Zealand paleontology was thriving. Otago and Victoria universities, in particular, had very active paleontology teaching programmes backed by strong research areas in mid-Cenozoic paleoclimate and marine vertebrate studies at Otago and Antarctic paleoclimate studies at Victoria. GNS Science had a large multidisciplinary team of paleontologists and paleontology technicians with particular strengths in integrated biostratigraphy and multiple proxy paleoclimate and paleoenvironmental research. Other universities and even NIWA had small but active paleontology teams.

For GNS, the diverse research and consultancy work of the last 30 years has its foundations in a hugely active phase of fundamental research in the 1960s to 1980s, where paleontologists of its predecessor, the NZ Geological Survey, established key South Pacific biozonations for molluscs, graptolites, terrestrial spores and pollen, dinoflagellate cysts, foraminifera and calcareous nannofossils. This research was underpinned by an expanding National Paleontology Collection and the globally unique NZ Fossil Record File. As NZGS transitioned to GNS in the 1990s, these foundational studies proved invaluable in supporting GNS's Cretaceous-Cenozoic sedimentary basins programme and oil and gas consultancy. Subsequent success in PGSF and Marsden grants allowed GNS to channel paleontological expertise into paleoclimate and natural hazards research, culminating in mission-critical roles in local IODP expeditions. However, the tide has now turned. Despite ongoing interest from students, paleontology teaching capability at all NZ universities is at an all-time low. And despite ongoing global efforts to better understand the drivers of climate change throughout the Cenozoic, GNS Science has slashed capability in pre-Quaternary paleontology.

Solutions to this national decline in paleontology capability are complex, but two things would make a difference: (1) recognition by universities that paleontology remains a vibrant and enticing research area for students and (2) government funding focused on advancing knowledge rather than narrow economic outcomes.

Paleoseismology of the Hope Fault Conway section and evidence for along-system earthquake clustering

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The Hope Fault accommodates approximately 35% (~15 mm/yr) of the relative plate motion in the transition zone between the Alpine Fault and the southern Hikurangi Subduction Margin. We examined the paleoseismic history of the Hope Fault Conway section (HF-CS) and evidence for earthquake clustering along the plate boundary. We combine data from eight new excavations with reinterpretations of previous studies from the Kahutara and Green Burn locations along a 2.5 km length of the HF-CS. These data constrain the timing of at least 13 earthquakes over the last 12,000 years; however, the paleoseismic record is discontinuous with significant unconformities between 3630 - 2000 and 8330 - 5430 cal. yr BP. The five most recent surface-rupturing earthquakes are interpreted to have occurred at 230 – 120 cal. yr BP (E1), 450 - 340 cal. yr BP (E2), 660 - 420 cal. yr BP (E3), 1250 – 1110 cal. yr BP (E4) and 2000 – 1830 cal. yr BP (E5). Five additional earthquakes (E6-E10) were derived from Heke Ngahere 3 trench between 5430 - 3630 cal. yr BP and three earthquakes (E11-E13) from Heke Ngahere 2 trench between 11340 – 8330 cal. yr BP. Comparison of the timing of these earthquakes with those on the Alpine Fault, Kekerengu Fault and southern Hikurangi subduction interface provides evidence for some temporal clustering of events along the hard-linked fault system. This clustering is most pronounced for adjacent faults. For example, 60% of all surface-rupturing earthquake timings on the HF-CS and the Kekerengu Fault overlap. Clustering supports the stress-transfer hypothesis, which produces either multi-fault ruptures and/or earthquake sequences.

Numeric modelling insights into the cause of shallow tremor at Ruapehu

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Shallow volcanic tremor - a long lasting yet periodic seismic signal is frequently seen during unrest periods and often precedes eruption. Due to the timing of such signals and potential for it to aid in forecasting volcanic eruptions, understanding the origin of these signals is important. A leading theory involves tremor being caused by breakaway outgassing of volatiles, which had been sealed from under a permeable cap. However the details of this mechanism, along with the type of tremor, varies based on location. This variation in tremor can be found within the 0.1- to 15-Hz range and in one of three amplitude spectra; single spectra peak (monochromatic) or in multiple spaced or uncorrelated spectra peaks (harmonic or broadband respectively). In 2022, harmonic tremor was observed at Ruapehu, New Zealand. This harmonic tremor is thought to be a result of continuous sealing and breaking of an elemental sulphur cap. Our project is set to numerically model these variations of volcanic tremor at Ruapehu, and determine how the tremor at Ruapehu occurs. We hypothesise that this work will contribute to using volcanic tremor as a legitimate means of monitoring the volcano.

Attenuation imaging of the Taupō Volcanic Zone

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The crust of the Taupō Volcanic Zone (TVZ) has been extensively altered by multiple generations of magmatic and geothermal systems. This has resulted in a highly complex three-dimensional structure which has long been recognised as the most seismically attenuating region of New Zealand. In this study we use 17 years of earthquake activity to perform seismic attenuation tomography and mapping of the TVZ crust. Results show multiple high scattering and absorption features which correlate with known surface activity. The three-dimensional observations reveal an interconnected system of magmatic and geothermal fluids. This will allow for a more detailed understanding of active processes, including volcano monitoring and geothermal prospecting.

Effective and ineffective strategies in science-society interactions for palaeontology: experience of last 15 years in Russia and its potential application to New Zealand

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Palaeontology is a branch of Earth sciences with well-established, long, over 250-year, traditions of interaction with society. Unlike many other sections of Earth Sciences, the subjects of study remain accessible for the wider public, while methods of study range from simple deductions based on occasional observations and single finds, through statistical studies of fossil populations and assemblages, to complex instrumental-based research. This feature makes palaeontological research accessible to people with different educational grounds, giving a chance to everybody to make a small or big scientific discovery.

However, the role of palaeontology in educating modern society still appears to be not only underestimated, but also under-monetised, especially if we consider very high excitement of people about dinosaurs, heated by Hollywood movies, and the co-existing toy industry.

Based on my own previous experience from Russia, I discuss some effective (as well as less effective) strategies that explore interaction of science and society, including, where applicable, their business models. These will be exemplified by four real, existing projects and businesses, which include: (1) an old-format paper media (glossy journal), (2) a specialised web-portal with scientific news, (3) palaeontology-devoted social network, and (4) a service connected with leisure and entertainment, i.e., geological tours and palaeontological master-classes. Taking into consideration local conditions, many of the discussed models of science-society interactions, and basic principles grounding them can be successfully introduced to NZ.

Data is a taonga - governance of Māori data in Crown Research Institutes

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Good practices around governance of data are essential to establish trust and benefit with data users, data contributors and the wider community. In Aotearoa New Zealand there has been an important conversation about how to embed Māori data governance into the governance of data about people, place or the environment. Within the Crown-Research Institutes there has been joint work identifying principles for the governance of data with Te Tiriti at the centre. In addition the separate organisations have codesigned projects with Māori partners to enable Māori data governance. With the establishment of the new Public Research Organisations there is an opportunity to fully embed Māori data governance into the Institutes. Here we will describe some of the initiatives, some key learnings and future directions.

Probing the Wairakei-Tauhara Geothermal System, Taupō Volcanic Zone, with a dense nodal seismic array

Chengxin Jiang[1], Prof. Meghan Miller[1], Finnigan Illsley-Kemp[2], Eleanor Mestel[2], Bethany Hughes[2,3], John Townend[2], Bridget Ayling[4]
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As the world transitions to clean energy and zero-emission technologies, the demand for sustainable subsurface energy resources is steadily increasing. In this study, we utilise a passive seismic approach with a dense nodal seismic array to enhance our understanding of the subsurface at the Wairakei-Tauhara Geothermal System in the Taupō Volcanic Zone, the first geothermal system for energy extraction in New Zealand. In 2024, 141 nodal seismic sensors supported by the Australian National Seismic Imaging Resource (ANSIR) were deployed across the 20 x 25 km² region centred at the Wairakei geothermal field in two phases, each lasting one month but with slightly different configurations. The array achieved an average station spacing of 3-5 km on a regional scale, with refined inter-station spacing of 200-500 m in several critical areas, such as Te Mihi and Poihipi. To best image the complex subsurface structure with the nodes data, we developed an adaptive irregular grid tomography method based on the Poisson-Voronoi approach. This enables multi-scale structural resolution while maintaining coverage in sparsely sampled regions with a comprehensive model. The resulting velocity model offers detailed structural insights from the surface down to a depth of 10 km, revealing features related to the shallow geothermal system, a glimpse of the deeper magmatic systems, and their possible connections. These structures will be evaluated for their potential functions as migration pathways and storage sites for geothermal energy, thereby enhancing our understanding of geothermal energy generation in complex geological settings.

Long period ground motion simulations of the Alpine Fault in the North Island using ambient seismic noise towards earthquake early warning

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The Alpine Fault is recognized as the primary seismic hazard in Southern New Zealand, capable of producing M7-8 earthquakes approximately every 300 years; it last ruptured in 1717 AD. There is a lack of empirical data on ground shaking due to the absence of recorded earthquakes from the Alpine Fault. Hence, the challenge is to compute realistic ground motions generated by various plausible rupture scenarios from the anticipated major Alpine Fault earthquake. The recent Myanmar and Kahramanmaras earthquakes have demonstrated that damaging shaking can occur as far as 1000 km from the epicenter. Auckland seats 800km away from the northern tip of the Alpine fault. Therefore, we aim to investigate the feasibility of an earthquake early warning system for the next Alpine Fault earthquake and target specific locations throughout the North Island, which are at least 600 km away from the earthquake source. By analyzing ambient seismic noise recorded at multiple stations simultaneously, we can study wave propagation between these stations without the need for an actual earthquake. Experimental and theoretical evidence has shown that ambient seismic noise can effectively constrain realistic Green's functions. These Ambient Noise Green's functions are modified from a surface point-force source to a double-couple source at depth, to estimate ground shaking for the Alpine Fault using the virtual earthquake approach. This methodology allows us to investigate different rupture scenarios and simulate ground motion in specific areas of North Island. This will allow us to assess the need and feasibility of an EEWS for these distances in the New Zealand context. In this presentation we will introduce the method behind the simulated ground motions, their potential impact on the human and build environments and benefits of an EEWS.

From source to impacts: advances in real-time analysis of NZ's big quakes through the RCET programme

Anna Kaiser[1], Bill Fry[1], Jen Andrews[1], Emmanuel Caballero[1], Nick Horspool[1], Emily Warren-Smith[1], Florent Aden[1], Calum Chamberlain[2], Danielle Charlton[1], Solen Chanony[3], Elisabetta D'Anastasio[1], r Tatiana Goded[1], Anthony Jamelot[4], Luce Lacoua[3], Chris Zweck[1], Katie Jacobs[1], Biljana Lukovic[1], Chris Massey[1], RCET Team[1]
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The recently concluded five-year RCET Endeavour programme has developed, tested and operationalized a suite of new complementary rapid earthquake characterisation tools. These tools provide a step change in situational awareness for responders in the minutes to hours following a major earthquake (and tsunami).

Here, we present an overview of RCET advances for large local earthquakes (Pacific tsunami covered in Fry et al. 2025 GSNZ).
RCET earthquake tools characterize the:

- earthquake source, incl. rupture extent, propagation direction and duration, magnitude, focal mechanism, energy release, slip.
- aftershocks, i.e. automated detection, mapping and characterization
- shaking, i.e. Shaking Layers (co-developed with GeoNet)
- impacts, i.e. RiskScape Rapid - exposed population (co-developed with RiskScape)
- tsunami potential

A key achievement is the creation of a rapid analysis pipeline from 3D rupture > shaking > impact, so that the impacts from our largest earthquakes can now be meaningfully assessed during time-critical response. Underpinning this capability, are our advanced earthquake source analysis tools (e.g. FinDer, GFAST-NZ, RTEQcorrscan) that estimate the spatial extent and evolution of large ruptures across tens to hundreds of kilometres.

The tools are now used routinely in ESNZ 24/7 operational response, including earthquake and tsunami expert panels. Most tools run in real-time and can also be operated by specialist science responders who review, interpret and refine solutions as needed. The combined power of real-time implementation, and on-hand specialist expertise, significantly speeds up the generation of time-critical bespoke event advice.

Using simulated examples, we illustrate what science could tell us in the first few hours after a devastating M8+ Alpine Fault and Hikurangi subduction earthquake, and how far we have come in situational awareness since the 2016 M7.8 Kaikōura earthquake. We also outline the steps we still need to take, with a future focus on tsunami and earthquake 'impact-based' early warning.

Geophysical imaging of the Paeroa Fault: insights from a dense nodal seismic array

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The Paeroa Fault is one of the longest and most active multi-strand faults in the Taupō Rift, capable of generating Mw6.8+ ruptures on a millennial timescale. At its northern end the Paeroa Fault splays into the Ngapouri fault, and is surrounded by several active geothermal features. Mapping the fault strands and their dip angle is important to understand earthquake hazards, fluid flow pathways and links between faulting, volcanism, and geothermal activity.

Over the summer of 2023/24 we deployed a dense nodal seismic array (DNSA) across the northern termination of the Paeroa fault, straddling the deep resistivity boundary along the northern boundary of the Waiotapu and Waimangu geothermal systems. The survey deployed 147 short-period and broadband nodal seismometers recording continuously for a period of ~4 weeks, and collected new closely spaced gravity data.

In initial analysis we have cross-correlated and stacked more than 1000 station-station pairs. The derived dispersion spectra for station-station pairs show clean fundamental surface-wave dispersion for Z-Z components for frequencies between 0.3 and 2 Hz. We will apply additional processing approaches to also retrieve higher modes, and to retrieve information for a wider bandwidth. We will then jointly invert the Rayleigh and Love dispersion curves to construct a three-dimensional S-wave velocity model, likely imaging to c. 2 km in depth across the spatial extent of the array for combined interpretation with a new 3D gravity model of the area.

We anticipate that our derived 3-D S-wave velocity model will reflect the subsurface heterogeneity across the Paeroa Fault, as well as imaging the northern boundary of the Waimangu and Waiotapu geothermal systems, delineating subsurface faults associated with local seismicity.

With this study we aim to show that DNSA surveys and ambient noise can be an effective tool for characterising shallow crustal structures in the Taupō Volcanic Zone.

Geophysical characterisation of landsides across Aotearoa

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Landslides occur in different rock types and at different scales across Aotearoa. Understanding the geometry of surfaces that control landslide development, and the materials in both the footwall and landslide block are important for building 3D models and ultimately understanding their behaviour. Earth Sciences New Zealand has collaborated with university teams to apply geophysical methods to characterise landslides over different regimes in response to events. The geophysical methods applied include electrical resistivity tomography (ERT), electromagnetic sounding (TEM and SkyTEM), and seismic (Seismic refraction, Multi-channel Analysis of Surface waves, and ambient noise sounding). Using a diverse range of geophysical tools allows a wider range of rock properties to be mapped that leads to understanding different aspects of the landslide.

Electrical resistivity is providing insight into the geometry of the existing slope, the level of saturation in surficial deposits, and clay content that might be key to identifying sliding surfaces. Ground-based methods provide detailed images while airborne methods produce an overview of the slopes and landslides. Seismic methods provide details on the compressional and shear wave velocities as well as geometry. The seismic velocity data provide starting points for determining the geomechanical properties needed for modelling deformation. Collecting seismic data in steep uneven terrain is a challenge so careful planning of profiles is needed.

The geophysical sections are valuable for targeting follow-up drilling, and form part of an integrated 3D modelling approach to landslide mapping. The work covers landslides from a range of bedrock lithologies including Alpine schist (Fox Glacier), greywacke (Kaikōura) and Tertiary limestone (Clarence), sandstone (Waiau), siltstone and mudstone (Te Puia, Tairāwhiti)). The interaction with Quaternary cover is also imaged in many geophysical surveys (Tāhunanui). Modern acquisition methods coupled with processing and inversion and incorporation or rock-properties from borehole data result in a more accurate model for engineering geological analysis.

Modelling fire hazard from lava flows in the Auckland Volcanic Field

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Fire following volcanic activity (FFVA) is a recognised but understudied hazard capable of causing severe damage to infrastructure and communities. Despite evidence from past eruptions demonstrating its destructive potential, there is a relatively limited understanding of FFVA to inform emergency planning and decision-making effectively. FFVA could pose a significant risk in Aotearoa New Zealand, with Auckland especially vulnerable since the Auckland Volcanic Field lies beneath a dense urban environment home to over 1.6 million people. Here, we examine how FFVA could amplify the impacts of a lava-forming eruption on Auckland's built environment. We applied an FFVA framework to a hypothetical eruption scenario centred on the suburb of Mt. Eden to model lava-induced ignitions and subsequent fire spread under varying environmental and fuel bed conditions. A sensitivity analysis examined the influence of vegetation heterogeneity and seasonal conditions on burn zone formation. A GIS-based impact assessment quantifying the direct building losses associated with lava flows and the additional losses from fire spread showed that lava-triggered fires could increase building-related losses by up to NZ$11 billion. Our results show that lava-induced fire warrants consideration by emergency management and planning, particularly under conditions where wind speed and direction enable fire spread (e.g., moderate to severe fire weather), during dry periods that prime fuels for ignition, and where lava interacts with ignition-susceptible assets such as residential dwellings in urban environments like Auckland. Although fire hazard remained within Auckland's likely evacuation zone in the event of a future eruption (9 km radius around the vent), our findings highlight the need to consider cascading consequences in volcanic risk assessments in Auckland.

Hydrothermal mineralisation prior to gas-driven eruptions: constraints on mineral seal formation via flow-through experiments

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Gas-driven volcanic eruptions (phreatic eruptions) occur regularly, most often associated with andesite volcanoes with active hydrothermal systems. These eruptions are inherently difficult to forecast, and eruption onset is one of the key challenges in volcanology. Some exciting progress has been made in automated analysis of unrest signals; however our understanding of the hydrothermal processes remains elusive. Hydrothermal minerals are known to form a blockage prior to gas-driven eruptions, yet the kinetics, and strength of that blockage requires attention before we are to understand subsurface processes responsible for priming and eruption.

Here we use a combination of large temperature gradient and static temperature experiments using a flow-through reactor at elevated temperature and pressure; a set-up that has been used extensively for assessing geothermal reactions. We filled the vessel with andesite granules, and percolated acidic hydrothermal fluids through them, to simulate flow into fumarolic conduits.

Our results show that within weeks, a mineral seal had formed, efficiently restricting fluid flow, resulting in significant pressurisation to failure. Hydrothermal minerals present in our experiments are dominantly alunite and anhydrite, with minor elemental sulfur, and rare accessory phases (pyrite, monazite). This mineral assemblage formed at ~150-180 °C and matches with hydrothermal phases present in ejecta from gas-driven eruptions globally. Analysis of the reacted effluent fluid show clear trends during hydrothermal seal formation. Using these data, we have begun to re-define geochemical changes occurring in hydrothermal systems, including crater lakes, in the lead up to failure. Coupled with the full suite of monitoring data, we are aiming to fundamentally improve gas-driven eruption forecasting.

Seismotectonic source zones and seismic hazard in the Kenya Rift

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Seismicity and seismogenic faulting are a key indicator of active tectonics in the Kenya Rift, which forms an eastern segment of the East Africa Rift System, marked by ongoing volcanism and magmatic processes. Despite its significance, uncertainties remain in our understanding of the seismic hazard in the region. We present a seismic hazard analysis of the Kenya Rift, based on analysis of earthquake data from 1912 to 2023, earthquake faulting, GPS velocity data and definition of area sources. A total of 2,967 earthquake events were analyzed from various sources (USGS, ISC, ESARSWG). Of these, 375 duplicate events were removed and the remaining events were converted to moment magnitude, the time-magnitude distribution was evaluated with catalogue completeness and b-value analyses. Based on the prevailing Kenya Rift fault system and spatial seismicity distribution, we identify 15 area source zones. GPS velocity data from Saria et al. (2014) were collected to plot a velocity-strain map, together with the focal mechanism of the 1928 Subukia earthquake.

The preliminary findings show widespread seismicity with clusters in the central and southern part of the active zones, indicating areas of potential seismic hazard. GPS velocity strain maps show ongoing crustal extension and focal mechanisms confirm dominant normal faulting in the Kenya Rift. These results identify key seismotectonic sources and zones of potential earthquake activity, providing essential inputs for fault-based probabilistic seismic hazard assessments and risk mitigation in the Kenya Rift.

CO_2 capture and storage in Aotearoa, New Zealand: are geothermal reservoirs rocks capable of carbon mineralization?

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Carbon capture, utilization, and storage in geologic formations is becoming an increasingly attractive option for mitigating anthropogenic carbon dioxide production. One source of CO_2 is geothermal power production due to outgassing. Recent efforts have been made to reinject this CO_2into the reservoir, mitigating subsequent climatic effects. Unfortunately, introducing CO_2could adversely affect the reservoir, reducing power production. To determine the extent to which geothermal reservoirs can store CO_2while mitigating any negative effects, a comprehensive evaluation combining modelling on the field scale and experimental analysis of available lithologies is paramount. Initial modelling studies show that the reinjection of CO_2sourced from the reservoir during power production has negligible consequences (Saihaan et al., 2024a; Saihaan et al., 2024b). Therefore, storing external CO_2using the same technique may be possible. Carbon is ideally stored through carbonate mineralization, where CO_2binds to divalent cations to produce non-toxic and permanent carbonate minerals. Mafic rocks have demonstrated the capability to mineralize CO_2in this way. However, most geothermal power plants are hosted in silicic reservoirs, which have not been studied sufficiently to determine their viability as a carbon storage option. To shrink this knowledge gap, this project outlines a series of experiments testing how temperature, lithology/hydrothermal alteration, fluid composition, petrophysical properties, and aqueous CO_2concentrations influence the capability of silicic geothermal reservoir rocks to mineralize CO_2. Core samples from geothermal wells within the Taupo Volcanic Zone, Aotearoa, New Zealand, will be analysed before and after being reacted in a brine + CO_2solution to assess the aforementioned variables. These analyses include the spatial distribution of elements in the sample, surface topography/texture, porosity, permeability, and elastic properties. The penultimate goal of this project is to define optimal conditions under which CO_2will mineralize within New Zealand geothermal reservoirs.

Complex building damage at lava flow margins: insights from the 2021 Tajogaite eruption, La Palma

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The 2021 Tajogaite eruption on La Palma, Canary Islands, Spain, caused widespread destruction and displacement with lava flows inundating communities downslope of the new vent. As in the Auckland Volcanic Field, the uncertainty of vent opening locations poses major challenges for hazard forecasting and emergency response in urbanised volcanic regions.

To better understand how lava flows impact the built environment we conducted a detailed assessment of structures, mostly people's homes, at the flow margins. A Damage State was assigned to each affected building using a combination of drone-derived aerial imagery and footage, and post-eruption ground investigations. Our damage assessment was then compared to the assigned damage rating from the satellite-based Copernicus rapid mapping results. This multi-scale approach enabled us to directly compare the limitations of remote methods against in situ observations.

Our results show that damage to residential buildings is often complex and non-binary. Partial collapses, roof and wall damage, lava flow inundation, and lateral displacement were common, yet these features were difficult to identify in satellite data. Drone and ground observations revealed more nuanced outcomes.

This study highlights the importance of integrating multiple observational scales for post-eruption assessments, particularly through the stress of an ongoing eruption when displaced families are anxiously waiting to learn the fate of their homes. Relying solely on satellite data risks oversimplifying impacts and misinforming decision-making in real time. By improving how we capture and assess building damage we can advance scientific understanding and also support more compassionate communication with affected communities within urban volcanic environments, such as Auckland here in Aotearoa.

Sedimentary evolution of the Rangitāiki Plains in Aotearoa New Zealand: implications for coastal processes and management

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The Rangitāiki Plains have prograded ~10 km over the past 6,500 years. Situated in a subsiding part of the Taupō Volcanic Zone, the shoreline advanced via infilling of mixed siliciclastic-volcaniclastic sediments. This outbuilding resulted in the deposition of beach ridges, which recorded the nature and chronology of coastal progradation. However, several beach ridge systems remain undated or are only constrained by tephrochronological correlations, resulting in gaps in the reconstruction of progradation rates and gaps in our understanding of environmental changes, shoreline evolution, sediment supply, storm activity, and sea-level fluctuations.

To address these gaps we integrated light detection and ranging (LiDAR), ground penetrating radar (GPR), optically stimulated luminescence (OSL) dating, and geochemical analyses (XRF, XRD). The goal was to refine the chronology and investigate the timing, rates, and controlling mechanisms of Holocene coastal progradation. LiDAR revealed the modern morphology and ridge patterns, allowing us to identify five major beach-ridge systems and three minor stranded ridges aligned parallel to the northwest-southeast-orientated modern coastline. OSL dating provided a refined chronology of ridge formation, giving absolute dates to ridges and establishing new progradation rates. Since 7.6 ± 0.6 ka, the coastline has advanced approximately 7.95 km at an average rate of 1.04 m/yr, with peak progradation rates around 5 ka (up to 43.03 m/yr) declining to less than 1.14 m/yr by 4 ka. GPR images revealed previously undocumented subsurface stratigraphy and suggested variation in the direction of progradation. Geochemical and textural data show consistent sediment composition between ridges; medium-grained, moderately well-sorted sands dominated by quartz, plagioclase, and mica.

Our findings advance our understanding of the chronology of progradation of the Rangitāiki Plains and the processes driving coastal evolution in this volcaniclastic sedimentary system. Results are valuable for coastal management and planning in mixed-source, sediment-rich environments across Aotearoa New Zealand and other volcaniclastic settings.

Illuminating Earth: how synchrotron light can answer geoscience questions

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Understanding Earth processes often relies on interpreting tiny samples to explain events that span vast spatial and temporal scales. This makes extracting the maximum possible information from each sample essential—yet doing so can be limited by access to high-performance analytical tools. Synchrotron-based techniques offer a solution, providing faster, more accurate, and more sensitive data than many traditional lab-based methods.

The Australian Synchrotron is a 3 GeV accelerator light source that utilises synchrotron radiation for a wide variety of applications. With 15 beamlines (expanding to 18 by 2027) and utilises extremely bright synchrotron radiation to support a broad suite of analytical capabilities. These include high-resolution imaging, trace-element and structural mapping, and advanced spectroscopic techniques such as XANES and EXAFS — providing unique insights into the composition and structure of Earth materials.

This talk will present some key research highlights from around the synchrotron. These will show the application of synchrotron techniques to geosciences, including understanding volcanic eruption mechanisms, mineralisation of REEs, and addressing mine waste's impact on the environment. Lastly, we will cover methods for users to access the Australian Synchrotron, and some advice on preparing proposals for the best chances of being awarded beamtime.

Whose role is it anyway? A survey on public perceptions of emergency management during geohazards response

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Recent severe weather events have shown a need for improvement in communication during geohazard and severe weather events. This study examines public knowledge of the emergency management system in Aotearoa New Zealand, with a focus on awareness of the roles and responsibilities of individuals, communities, and official agencies during disaster events. We explore perceptions of preparedness and capacity across various groups, from personal networks like family and friends, to local organizations such as religious and sports groups, and national-level responders including police and civil defence authorities. The survey results reveal gaps in public understanding and highlight opportunities to strengthen emergency communication and planning. This poster presents key findings and their implications for enhancing disaster preparedness response and communication strategies.

We posed a set of 22 questions asking respondents to select which agencies they expect would be involved in different tasks across the four stages of reduction, readiness, response and recovery to identify if any disconnects exist between publics expectations for response and the reality of government mandated tasks. We queried what actions and roles the respondents would do to support response efforts to establish how the public view their own role in the emergency management system. This data will be shared with decision makers and emergency responders to allow for improvements in the system.

The geology of the Taupō Volcanic Zone at 1:130 000 scale

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We present the final in-review draft of the geology of the Taupō Volcanic Zone (TVZ), a digital and print map with accompanying full-colour bulletin. It is the first to focus particularly on the complete suite of Quaternary volcanoes and volcanic rocks of the TVZ. The rocks underlying and surrounding these volcanoes include those of the central Te Ahi Tupua caldera system and the stratovolcanoes (also referred to as composite cones) of Tongariro Volcanic Centre to the south, and Tūhua and Whakaari to the north. The TVZ is superimposed on the Taupō Rift and rocks overlap older volcanics of the Coromandel and Tauranga volcanic zones to the northwest, and the transpressionally faulted greywacke ranges to the east.

This 1:130 000-scale map has been redrawn using LiDAR-derived precise elevation data available in most areas. It accommodates and reconciles all available published and unpublished mapping, stratigraphic studies and geochronology to date. The TVZ is a roughly 270 by 60 km area encompassing eruptive vents. The map represents a revision of published QMAP sheets 4 to 7 with expanded detail and resolution of the volcanic geology and less emphasis on the basement rocks. It also incorporates generalised linework and stratigraphy from the recent geological map of Tongariro National Park area. The map covers a wide area across the central North Island as well as relevant offshore islands in the Bay of Plenty.

The bulletin describes all map units and summarises other relevant volcanic geological aspects. Accompanying the volcanism, particularly in the central TVZ, are numerous hydrothermal systems. Other resources include rock and aggregates (volcanic and non-volcanic) and extensive groundwater resources in the permeable volcanic rocks. The area is also a major focus of tourism, especially around the cone volcanoes of Tongariro National Park and the hot springs of the Rotorua district.

New volcano hazard research supporting emergency planning in Auckland: seventeen years of DEVORA

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The likelihood of an Auckland eruption, the potential need for rapid widespread or total evacuation, and the cost of such an eruption have been acknowledged as a hazard of national significance and a priority to address. This highlights the national significance of both what is known and still unknown in the Auckland Volcanic Field.

The DEtermining VOlcanic Risk in Auckland DEVORA research programme is jointly funded by the Natural Hazards Commission and Auckland Council and co-led by the University of Auckland and Earth Sciences NZ. Over the past 17 years, it has produced hundreds of publications from most New Zealand universities and continues to make key advances.

New research in the USA on unusually well-preserved deposits indicates surges may travel 9km or more. Combined geochronology and tephra correlation shows a median and modal inter-eruption period in the last 60,000 years of ~500 years. A range of magma rise, spatial distribution and crustal structure studies continue to show a wide variation in potential rise paths, possible short warning periods (days), and the potential for for the magma source to be offset laterally. Other new studies are focusing on gas and fire hazard, probabilistic financial loss, CO2 at Rangitoto, and analogue lava and gas impacts overseas.

DEVORA scientists have used all of this information to support new Volcano Response Planning at Auckland Council and with NEMA and emergency services. This has highlighted outstanding critical research uncertainties, especially around detection of magma ascent (from a source region), potential rise paths and rates, localisation to vent location(s), the spatial ranges of hazards, especially surges, and the practicalities of evacuation. These considerations are driving the next DEVORA research priorities and larger funding bids in partnership with emergency management.

Scanning electron microscopy microcharacterization at the University of Auckland

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The Microcharacterisation Centre is the core facility of the Faculty of Science providing Scanning Electron Microscopy services. Presently, The Centre offers imaging and analysis services using the newly acquired TESCAN CLARA High-Resolution Field Emission Scanning Electron Microscope. With its high magnification, ultra-high spatial resolution capabilities and multiple detectors, this instrument is essential for multidisciplinary research at UoA Community, from geology to nanotechnology.

XRF fluorescence spectroscopy at the University of Auckland

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The S8 Tiger WDXRF Series-2 at the University of Auckland is renowned across the world for producing multi-element profiles (from carbon to uranium) of any type of material with a high degree of accuracy and speed. Universities and research organizations conduct fundamental investigations into novel materials; hence, analytical instruments must provide accurate data for element concentrations on a wide range of samples.

Modern X-ray fluorescence (XRF) equipment is outfitted with cutting-edge hardware and software, ensuring the finest analytical performance. At the same time, because they are simple to use, our XRF spectrometers are excellent for production settings. All-in-one equipment is available for checking raw material, monitoring manufacturing, and evaluating finished goods.

SEISYNC: an AI-driven modular seismic monitoring system for synchronous earthquake early warning and post-event cataloging

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The SEISYNC project aims to develop an AI-driven, modular seismic monitoring system capable of synchronously performing short-term earthquake early warning (EEW) and long-term earthquake cataloguing. Built upon the RED-PAN deep learning phase picker, SEISYNC integrates real-time P-wave detection for rapid event localization and magnitude estimation with near-real-time P–S pair tracking for detailed post-event analysis. Its scalable microservice architecture, leveraging Kafka-based event streaming, enables hot-swappable modules for flexible algorithm deployment. EEW components employ the equal-differential-time method for fast and robust localization, while cataloguing modules integrate GaMMA phase association with NonLinLoc 3D hypocenter determination. Future development includes a human–robot interface powered by large language models via the Model Context Protocol, enabling expert-in-the-loop analysis of seismicity patterns, structural models, and catalog updates. By unifying advanced AI algorithms, modular design, and interactive interpretation tools, SEISYNC targets enhanced operational efficiency, accuracy, and adaptability in earthquake monitoring across diverse tectonic settings. The SEISYNC project is updating with the latest algorithms and has been deployed in the Central Weather Administration in Taiwan. Here we examine the feasibility of the near real-time earthquake cataloguing modules with the past major events waveform playback, including the 2024 M7.4 Hualien earthquake in Taiwan, the 2010 M7.1 Darfield earthquake, the 2011 M6.2 Christchurch earthquake, and the 2016 M7.8 Kaikōura earthquake.

Origin of the Auckland Volcanic Field: insights from finite-frequency body-wave tomography

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We use finite-frequency body-wave tomography with new seismic stations to understand the genesis of intraplate volcanism in the Auckland Volcanic Field (AVF). Intraplate volcanism is distinct from volcanism near plate boundaries, as is not directly caused by plate extension or collision. Current hypotheses regarding the origin of intraplate volcanoes mainly focus on mantle plumes and lithospheric extension. The AVF, located in the northwestern part of New Zealand's North Island and far from the Hikurangi subduction zone, has an unclear origin. Previous geochemical studies have revealed that its magma composition differs significantly from that of the Taupo Volcanic Zone (TVZ), where magmatism is driven by fluid release from the subducting slab. It has been proposed that the magma beneath Auckland may originate from the vicinity of the mantle transition zone (MTZ), although other genetic mechanisms also warrant further investigation.

We utilize seismic data recorded by the New Zealand GEONET seismic network, 60 temporary stations deployed by the Southern University of Science and Technology (SUSTech) and the University of Auckland during 2023–2025, and 15 ocean-bottom seismographs (OBS) deployed and recovered by the SUSTech OBS Lab in 2023–2024 from offshore areas near the AVF.

Methodologically, we employ finite-frequency body-wave tomography, which differs from conventional ray-theoretical approaches by accounting for the frequency-dependent sensitivity of seismic waves. By incorporating data across multiple frequency bands, each of which is characterized by distinct sensitivity kernels, this method enables the resolution of multi-scale seismic velocity anomalies.

Our study focuses on imaging the seismic velocity structure of the MTZ and the overlying upper mantle beneath the North Island of New Zealand, with the aim of constraining the structure of the subducting slab and the surrounding mantle, and investigating the genetic mechanism of the AVF, thereby providing new insights into the formation of intraplate volcanism.

Kinematic evolution of slow-moving landslides in Northern California: impacts of precipitation and seismic activity (2021-2024)

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Between July 2021 and March 2024, slow-moving landslides in Northern California experienced both earthquake shaking and an abrupt transition from drought to above-average rainfall. It is well established that increases in precipitation accelerate landslides by raising pore-water pressure, reducing the effective normal stress on the basal shear zone, and thereby lowering frictional strength. However, the influence of earthquake-induced changes in permeability and fracture density, in conjunction with fluctuations in precipitation, is less well understood. We investigate whether peak ground shaking enhances fluid pathways to the basal sliding surface, modifying the landslide response beyond what would be expected from precipitation alone.

Using 14-day L-band InSAR displacement time series, we analyze both existing and newly identified landslide inventories that include hundreds of candidate landslides. These landslides share onset times for rain events, similar regolith properties, and hillslope angles, and span a region approximately 150 × 300 km. We extract displacement time series and perform a spatially comprehensive analysis of kinematic responses. When acceleration timing or magnitude is anomalous, we consider internal structural controls—such as landslide area, depth to sliding surface, and kinematic complexity—alongside external earthquake shaking. In particular, we examine whether strong ground motions from two M > 6 earthquakes in December 2022 and December 2023 are correlated with spatial outliers.

Seasonal to multiannual creep rate changes along the Hayward, Rodgers Creek, and Maacama faults, California

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Aseismic creep plays a crucial role in the seismic hazard associated with a given fault. Tectonic forces continuously load faults, and the amount of strain released through fault creep directly influences the amount of energy remaining in the system to drive large earthquakes. Creeping fault segments pose a lesser seismic hazard than fully locked faults by increasing the interval between large earthquakes or reducing the magnitude of potential events. Changes in the rate of fault creep reflect the state of stress acting on the slipping portion of that fault over short (e.g., slow slip events) and long (e.g., viscous relaxation) time scales, and therefore reflect the evolving seismic hazard associated with a fault throughout the seismic cycle.

We identify annual to decadal-scale changes in fault behavior on the Hayward, Rodgers Creek, and Maacama faults in northern California. We consider observations from an updated repeating micro-earthquake catalog, new surface creep rate estimates from InSAR, and existing terrestrial measurements from alignment arrays and creep meters. We process a 9-year ALOS-2 ScanSAR time series, which includes a 3-year period with near 14-day repeat intervals to constrain long-term surface creep rate estimates. Where C-band maintains coherence in urban areas, we complement the ALOS-2 with Sentinel-1 products and present seasonal creep variations in Willits, Santa Rosa, and along the Hayward Fault. Multi-annual creep rate changes along the Hayward Fault are imaged with Sentinel-1 time series and validated against creep meter time series. Decadal changes in Willits are highlighted with MWIL alignment array displacement time series and changes in CRE productivity. This project utilized the newly released North America Surface Displacement (DISP) data product managed by the Jet Propulsion Laboratory's (JPL) Observational Products for End-Users from Remote Sensing Analysis (OPERA) project, and ALOS-2 ScanSAR data available through a JAXA-NASA data sharing agreement.

Teaching volcanic crisis management and communication through authentic role-play: celebrating 13 years of the Auckland Volcanic Field eruption simulation exercise

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The Auckland Volcanic Field simulation is a role-play exercise that simulates a volcanic eruption in Auckland in which participants, acting as emergency managers and scientists, are tasked with responding to the evolving crisis. Originally developed by the Geoscience Education Research Group at the University of Canterbury, the exercise has been run annually as part of a geohazards postgraduate course at the University of Auckland since 2012 (including in simplified virtual format during the COVID pandemic). During the full-day exercise, held either in the Emergency Control Centre at Auckland Emergency Management or on the University Campus, 30–40 students role-play as emergency managers and scientists as they work together to address the developing unrest and eventual eruption and communicate the hazards and risks to various ‘stakeholders’ and ‘the public’. An important goal of the simulation is to improve participants’ science and crisis communication skills through interdisciplinary team discussions, mock media releases, high-pressure press conferences, media interviews and, in recent years, social media posts and responses to engagement and queries from ‘the public’. The simulation exposes participants to a realistic risk management experience, emphasising the value of effective communication, and of established relationships between scientists, emergency managers, and critical infrastructure providers when faced with the immediate deadlines and intense pressures of an eruption crisis. Past participants who have gone on to careers in emergency management, volcano monitoring, hazard and risk management, and crisis response have noted that the exercise was a valuable introduction to the real-world environment of crisis management. Recent modifications have streamlined and simplified the simulation, enabling it to be adapted and run by others, most recently by a group at the Laboratoire Magmas et Volcans in Clermont-Ferrand, France, interested in using the exercise for emergency managers and students focussed on the nearby potentially active Chaîne des Puys volcanic region.

Sustainable extractive metallurgy for the refining of critical minerals in Aotearoa

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Discussion of sustainable mining in New Zealand has focussed primarily on the extraction of ore bodies at the mine site. However, the dominant contributor to the overall value and sustainability of minerals is often their downstream refining. If the full economic potential of New Zealand's critical mineral resources is to be realised, greater focus needs to be given to their conversion to higher value materials.

But what are the boundaries of sustainable mineral processing in Aotearoa? Can existing extractive metallurgy processes fit within these bounds – and, if not, what alternatives are available?

In this work, we discuss the processes needed to refine critical mineral resources in New Zealand. We focus on advances in zero-liquid discharge, zero CO_2 emission, and low energy intensity processes.

As a case study, we present current and future refining practices for titanomagnetite ironsands. The experimental results of a five-year programme – developing zero-CO_2 hydrogen reduction for ironmaking and zero-liquid discharge leaching processes for vanadium extraction – are presented. The potential application of these approaches to West Coast ilmenite mineral sands is also discussed. Using a suite of analytical techniques such as SEM-EDS, XRF and XRD, we provide insights throughout the process chain to refine mineral to metal.

These results provide a model for future mineral refining in Aotearoa, supplying critical minerals without compromising sustainability.

Breaking the shallow-water speed limit – a large-scale experimental interrogation of tsunamigenic PDCs

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Pyroclastic Density Currents (PDCs) can generate tsunamis and cross significant waterbodies posing high risk to populations living in near-shore volcanic areas. Global hazard assessments urgently require models for mitigating this risk, but the hostility of flows limits internal observation of this enigmatic hazard process. By synthesizing PDC-water interactions in large-scale experiments, we demonstrate that three fundamentally different types of water waves occur, depending on the vertical density stratification of the parental density current. Through direct measurements of the sub-aerial and sub-aqueous flow regions, we show that the wavelength, wave celerity, the ratio of wavelength and water depth, and the wave energy, increase manifold with increasing concentration and mobility of the basal PDC flow region. Dilute turbulent surge-like PDCs generate low-energy shear-induced wind-waves. For concentrated pulse-like, finite-volume PDCs formed in low-volume eruptions, a higher energy, impulse wave occurs through the instantaneous transfer of the momentum from the frontal portion of the dense underflow of PDCs to the near-shore waterbody. The wave characteristics are similar to solitons, whose celerity is limited by the shallow-water speed. By contrast, for conditions of more sustained PDCs formed in sub-Plinian and Plinian eruptions, prolonged and near-complete momentum transfer from the mobile underflow onto the water occurs. This generates a super-critical high-energy, impulse wave whose wavelength and celerity increase beyond the shallow-water limit and until underflow motion ceases. This high-celerity wave can overtake earlier generated shallow-water, soliton-like waves, and has never been reported in experimental and numerical simulations. The types and characteristics of real-world waves can be predicted by considering the momentum fluxes and duration of natural PDC events. This discovery suggests that tsunami hazard models should consider generation of multiple waves by a single PDC and must account for the vertical density stratification and for temporally variable momentum of PDCs to accurately predict hazard impacts.

Detection of short-term slow slip events in New Zealand using decade-long GNSS time series

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Short-term slow slip events (SSEs) play a vital role in understanding stress accumulation and release along subduction zones, yet their detection remains challenging—particularly in regions like New Zealand's Hikurangi subduction margin. Despite hosting a wide spectrum of SSEs, the Hikurangi margin likely experiences numerous short-duration events that go undetected due to their small amplitudes and the presence of complex noise and nontectonic signals in GNSS data. Traditional detection approaches, such as visual inspection and threshold-based methods, are often insufficient for identifying these subtle signals, especially in offshore or low signal-to-noise environments.

To address these limitations, we apply an automated detection method, Singular Spectrum Analysis Isolate Detect (SSAID), previously validated using synthetic data from physics-based models and real GNSS observations in southwest Japan. In this study, we extend SSAID to over a decade of GNSS time series from the Hikurangi subduction zone. We assess detection performance using comparisons with nonvolcanic tremor activity, statistical hypothesis testing, and fault slip inversion. The resulting catalogue of short-term SSEs provides a more detailed picture of transient deformation in the region and offers fresh insights into the mechanisms controlling slow slip at subduction margins.

Something's got to give: highly heterogeneous deformation in the Ross ice shelf is associated with composite sutured zones

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Sea level rise adaptation is hampered by high uncertainty around the rate and timing of projected increases. Polar ice sheet melt dominates future sea level rise, but flux rates remain enigmatic due to insufficient understanding of ice sheet properties and processes. The most sensitive components of ice sheets are their fringing ice shelves, and their retreat de-buttresses inland ice and can trigger runaway ice loss into the oceans. Full-depth fracturing can lead to catastrophic disintegration of ice shelves; however, fracture propagation is often retarded by strips of anomalous ice that suture together ice from separate outlet glaciers. This is often attributed to high contents of warm, saline ice, yet direct observations are lacking. Conversely, little attention has been paid to the shear margins bounding these zones, which are inherited from upstream, and their effect on ice shelf kinematics.

We analyse various satellite data to assess the deformation and geometry of the Western Ross Ice Shelf, assess shelf ice provenance, and monitor the evolution deformation and structures during advection. Particle tracking and strain rate mapping show that both ice developed in-situ and inherited shear margins concentrate rapid deformation far into ice shelves along sutured zones, facilitating rapid throughput and limiting buttressing; therefore we propose these structures are best understood as composite sutured zones. A large-scale flow turn shows a pronounced strain rate anomaly, where elevated strain rates along composite sutured zones temporarily decrease mid-turn. We interpret this as pointing to anisotropic ice fabric, with local ice flow highly sensitive to fabric orientation relative to the stress field, as well suggesting self-reinforcing mechanics. These findings encourage consideration of structural heterogeneity and fabric anisotropy in ice shelf modelling, and additionally highlight the role of inherited shear margin ice in the mechanical effect that composite sutured zones exert on ice shelves.

Using the XAS and MEX beamlines at the Australian Synchrotron to analyse laterite ores undergoing critical metal extraction using Fe(II) meditated recrystallisation and reductive dissolution

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Critical metals such as nickel (Ni) and cobalt (Co), are essential for modern green technologies (e.g., solar panels, windmill turbines and batteries). The majority of the world's Ni reserves are associated with iron (oxyhydr)oxides or laterites, while Co is mostly a by-product of Ni and Cu mining. To extract Co and Ni from laterites we employed a metal extraction technique using Fe(II)-catalysed recrystallisation which promises less environmental impact than conventional Ni extraction techniques that often involve high-pressure acid leaching. Initially, a moderate amount of Ni was released but this was increased with the addition of more Fe(II) to the reaction. While the optimised reaction increased Ni release from 7% to 35%, Co release increased from 40% to nearly 100%. This led to the assumption that a reductive dissolution process is taking place and that the Co source is likely to be manganese oxide. As synchrotron radiation is useful in determining mineral phases, we used the MEX and XAS beamlines at the Australian synchrotron to identify the mineral phases that host the Ni and Co in the ore samples. Additionally, we used HERFD XAS, to confirm that the majority of Co is indeed hosted in the manganese oxides phase and undergoes significant changes during the leaching process. This useful information regarding the Ni and Co rich mineral phases pre and post leach is currently used to optimise the leach conditions to maximise the extraction conditions and is an important step towards our understanding of Fe(II)-catalysed recrystallisation and reductive dissolution as a metal extraction pathway with low environmental impact.

Do visual observations reflect volcanic gas emissions at Whakaari/White Island?

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Volcanic gas emissions are key indicators of volcanic unrest, reflecting subsurface processes such as magma ascent or permeability changes. However, direct gas measurements often require site access and specialised equipment, which can be difficult or dangerous to deploy at remote or active volcanoes.

Whakaari/White Island features persistent degassing and a crater lake. Before the 9 December 2019 eruption, on-site monitoring included three webcams capturing near-real-time images of visual conditions, and two differential optical absorption spectrometers (DOAS) measuring SO_2 flux. Since the eruption, there has been no access to the island, and on-site monitoring equipment has deteriorated to failure. As a result, monitoring now relies on remote tools like observation gas flights, remote camera footage, and remote sensing imagery. This study investigates whether visual observations from webcams, satellite imagery, and overflight photographs captured between 2015 and 2025 can serve as proxies for volcanic gas emissions by examining correlations between plume features and measured CO_2, SO_2, and H_2S fluxes.

We quantified plume size by segmentation and thresholding of webcam images, while all image types were qualitatively classified on a scale of low, medium, or high steam presence. To isolate gas flux effects, only images from days with relative humidity below 75% were considered. Preliminary results indicate no correlation between plume size and measured gas fluxes. This suggests plume size alone does not reliably reflect subsurface degassing, likely due to other factors like ambient atmospheric conditions, gas exit temperature or interactions with the hydrothermal system (e.g., buffering and mineral precipitation).

Ongoing analysis explores whether plume size relates to other visual observations such as crater lake presence, lake colour, or active vent conditions. Identifying consistent visual indicators of volcanic activity could support low-cost, remote monitoring at Whakaari and other volcanoes, enhancing early warning systems where access or on-island monitoring equipment is limited or absent.

Volcanic Lakes in Te Arawa: volcanic - environmental monitoring

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Here I present the application of technological advancements and new findings in the characterisation and monitoring of Volcanic Lakes in Te Arawa. We reflect on the use of our portable subaqueous volcanic toolkit in these lakes, and present a case study of research at Rotoiti, including a first 'Lake Carbon Budget' of accumulated volcanogenic CO_2 within the lake. We have utilized a portable-Remote Operated Vehicle (ROV), in-situ pCO_2 and water physiochemical sensors, and surface accumulation chambers to track the dispersal and influence of dissolved volcanogenic CO_2 in Te Arawa's volcanic lakes. These tools revolutionize the capacity for local monitoring groups to combine and enhance environmental and volcanic monitoring efforts in Volcanic Lake environments. Te Arawa is one of the original Māori voyaging waka, the descendants of its sailors now occupy the northern region of Ahi Tupua, within the Taupō Volcanic Zone (TVZ) that is dominated by geothermal activity across a multitude of volcanic calderas. Monitoring of these volcanic systems is conducted through routine environmental and hydrological initiatives conducted by local and regional councils, iwi trusts, and crown and private entities, but are largely restricted to subaerially exposed sources. We integrate new data with ongoing, historical, and cultural monitoring projects to provide baselines of new and relevant data for future subaqueous volcano monitoring, and support Te Ao Māori.

Te Tukohu Ngāwha – reflecting on five years of scientific growth steeped in Mātauranga Māori

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Te Arawa Lakes Trust have been running Te Tukohu Ngawha – Mātauranga Māori Science and Design Fair - for five years now, an event which has grown in popularity, reach, and competitiveness throughout its short life. This event invites primary school- aged students from across Te Arawa's rohe, and nationally as of 2025, to conduct scientific investigation steeped in Mātauranga Māori. This fair runs with the intention to encourage students to think about the state of their taiao and wai and the types of issues it may be facing. With the influence of Mātauranga Māori and western-inspired science, young people are invited to engage in science practices and processes that acknowledge mātauranga Māori and to come up with potential solutions to these issues that our taiao faces.

This initiative aims to to provide a space where tamariki and rangatahi can think about the issues that directly impact their taiao and wai, and can start to think of ideas or solutions to mitigate these issues through a te ao Māori lens, complimented with western science. This is more than just a science fair—it's a platform of creativity, innovation, and empowerment!
Categories for student competition include:

- Biosecurity
- Biodiversity & Conservation
- Mātauranga Māori
- Water Environments (Freshwater & Marine)
- Sustainability
- Climate Change Adaptation/Resilience

Awards offered include:

- Water New Zealand - Student and Teacher Award
- Te Kopu NZ - Te Anamata: Inquisitive Minds Award
- Bay of Plenty Regional Council - Te Mana o Te Wai Enhancement Supreme Award
- Toitū Whenua Land Information New Zealand - Award for Excellence in a Project Focused on the whenua
- Bay Conservation Alliance - Conservation Award
- SCION - Ngā Huarahi ki Te Ao Award
- Te Arawa Lakes Trust - Ngā Karu Atua Award

Collaborative learnings from the Volcanic Lakes of Ahi Tupua

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This talk will reflect on the role of Mātauranga throughout the author's PhD research. This research is rooted in collaboration with Te Arawa whānau; including operational co-creation, collaborating to produce educational programs, marae- based planning and results- sharing, and the formation of reciprocal relationships. This approach was born from the ashes of a damaged relationship and has presented the opportunity to engage meaningfully with the mātauranga of Te Arawa Kaupapa.
The mātauranga and kaupapa discussed with me by community members are not mine to share here, but I believe future research and monitoring initiatives can include the following tri-hybrid approach to engaging with Volcanic Lakes and their communities:

Volcanic history: Traditional purakau, local anecdotes, and regional geology provide three lenses with which to record historical activities.

Engaging with volcanic lakes today: Any relationship is built on respect - iwi maori or otherwise, requires repeat engagement, and would benefit from the training of local practitioners.
Future monitoring initiatives: Funding applications and science fairs can be directed to Tamariki to provide early education opportunities surrounding freshwater, hydrothermal, and geothermal environments; whilst engaging in mindful conversation with community members encourages continued investment in local research.

This co-creation with Te Arawa, and the history of broken trust, has also informed the approach taken to engagement with other iwi in the research area, particularly concerning Ngati Tuwharetoa; who have an interest in conducting and coordinating their rangahau mahi in the roto. From that perspective, we are working to train Tuwharetoa rangatahi and kaitiaki, from around Taupo Moana, in the application of portable volcanic monitoring tools.

Geochronology and geochemical evolution of magma systems in the Taupō-Maroa area between two supereruptions: Whakamaru and Ōruanui

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The two most recent supereruptions in the central Taupō Volcanic Zone (TVZ), Whakamaru (349 ka) and Ōruanui (25.4 ka), have been well characterised by previous petrological and geochemical investigations. However, what happens to magmatic systems and the processes that occur between these vast events can be challenging to determine. The high frequency of rhyolitic eruptions in the TVZ between supereruptions, mostly as lava domes, present the opportunity to assess the temporal variability and evolution of magmatic systems in the Taupō-Maroa area between 349 and 25.4 ka. Lavas and pyroclastic deposits spanning this 325 kyr period have been studied using field mapping, petrographic descriptions, ^{40}Ar-^{39}Ar dating, major and trace element geochemistry, Sr isotopes and mineral chemistry. This work shows there were six distinctive magma systems in existence comprising 11 magma types, between the Whakamaru and Ōruanui events. These six magma systems had deeper crustal roots that can be linked to the two major crustal greywacke terranes: Waipapa and Kaweka. Lavas of the Western Dome Belt age-bracket the Whakamaru event and indicate the existence of a long-lived magmatic system that was seemingly uninfluenced by the adjoining much larger Whakamaru system. Lava dome distributions are influenced by regional and local tectonic structures and dome eruptions occurred more frequently than previously thought, suggesting that the most common eruptive mode of rhyolitic caldera volcanoes is dome-building activity. The temporal and spatial patterns of large ignimbrite versus dome-building eruptions strongly implies that the thermal flux needed to drive such large explosive eruptions varied greatly in intensity and moved around in the 349-25.4 ka period.

Ka hangaia ngā mātauranga hou

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Scientific observations made over millennia in Te Moana-nui-a-Kiwa and then Aotearoa, provided a blueprint of living with the taiao from which Māori culture was created from since the earliest Polynesian ancestors arrived. Mātauranga-a-iwi and mātauranga-a-hapū belong to the iwi and hapū collective and their descendants and should not be disseminated by others otherwise it removes their tino rangatiratanga and ownership over their own knowledge. This mātauranga-a-tapu (valuable mātauranga distinct to iwi and hapū) is encoded into our reo, toi Māori (e.g. tukutuku), place names, given names, pūrākau and whakataukī, also known as, mātauranga Māori. Since Māori are generally a visual people, it is this very method (visual, sound, kinetic) which enables core mātauranga to be encapsulated in the oral and visual arts of Māori, to transcend time. Hence mātauranga Māori is a continuous concept, not static, nor is it relegated to the past. To understand some of the scientific methods developed by Western scientists, it is useful to think of them through a Te Ao Māori worldview. Whakapapa is a fundamental concept deeply rooted in Te Ao Māori. The root of the word whakapapa and the disciplines of geology and chemistry combine to encode data obtained through these disciplines into a Te Ao Māori framework/whakaaro Māori way of thinking, thus developing new mātauranga Māori.

Investigting hydrothermal sealing mechanisms at Mt Ruapehu using SO_2 emission rates

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In June 2022, GeoNet, in collaboration with the NOVAC (Network for Observation of Volcanic and Atmospheric Change) community, installed four scanning mini-Differential Optical Absorption Spectrometers (DOAS) around Mount Ruapehu. These instruments collect SO_2 emission rate data every five minutes during daylight hours, providing the first semi-continuous record of SO_2 emissions from the volcano.

Since full deployment in May 2022, observed SO_2 emission rates have ranged from 0 to 10.7 kg/s. This high-frequency dataset offers unprecedented insights into short-term variations in gas release from vents beneath Te Wai ā-moe (Ruapehu Crater lake). It has proven especially valuable for monitoring volcanic activity, particularly when integrated with complementary datasets.

One key application has been the study of hydrothermal sealing. Periods of undetectable SO_2 emission rates, often coinciding with low lake temperatures and lasting several months, have been followed by sudden spikes in SO_2 emission rate—indicating seal rupture due to gas overpressure. During one lake sampling event, large sulfur slicks were observed floating on the lake surface, occurring a day after a peak SO_2 emission rate of 5 kg/s was recorded on 7 July 2025 (the highest for the period). This event was preceded by a smaller but sharp increase in emissions, followed by a return to undetectable levels over a prolonged period.

In contrast, the most recent and highest SO_2 emission rate event—9.3 kg/s recorded on 14 July 2025—was accompanied by a gradual rise in lake temperature and sustained SO_2 emissions, suggesting complete seal removal.

These observations demonstrate that continuous monitoring of SO_2 emission rates is a powerful tool for understanding hydrothermal sealing dynamics and may contribute significantly to forecasting future phreatic eruptions at Ruapehu.

Holocene landscape evolution and phases of accelerated sedimentation and dune building in the lower Wairarapa Valley, North Island, New Zealand

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This study reconstructs the Holocene evolution of former-Wairarapa Bay and its surrounding sedimentary landforms as it transitioned to become modern day Lake Wairarapa in the Lower North Island of New Zealand. Specifically, we test the hypothesis that phases of sedimentation and dune building were associated with seismically enhanced sediment supply. We tested this using a combination of geomorphic mapping, radiocarbon and optically stimulated luminescence dating of dune deposits and floodplain sediment cores, and measurement of in-situ10Be cosmogenic nuclide concentrations in sediments.

Our findings suggest that during the early to mid-Holocene, the coastal basin underwent substantial fluvial infilling. During this period there is no evidence for dune development - likely due to unfavourable conditions for formation or preservation along the lake margin. Dune building commenced around 4,000 years ago (Kahutara phase), coinciding with a regional sea-level fall. Seismic activity along the Wairarapa fault and/or Hikurangi subduction zone may have enhanced sediment supply and created conditions conducive to aeolian deposition at this time.

Around 3,000 years ago, a major reconfiguration of the fluvial system occurred, likely due to avulsion of the Waiohine River into the Ruamahanga, as supported by previous lake core data. This shift preceded a second major dune-building phase (Judds) at approximately 2,200 years ago, again potentially linked to seismic activity and lower lake levels.

A third, smaller dune-building phase (Parera) followed, also near-synchronous with earthquakes, though reduced tidal influence may have limited dune development. The 1855 Wairarapa earthquake was not followed by notable dune formation, possibly due to diminished tidal dynamics and higher lake levels, but we note some small, undated dunes near the lake margin.

These findings underscore the interplay between tectonics, hydrology, and sediment dynamics in shaping the Wairarapa landscape, and highlight episodic phases of dune formation and fluvial infilling during a transition from marine to lacustrine conditions.

Vegetation change over the Mid-Pleistocene Transition in Aotearoa-New Zealand: insights from a Hikurangi Subduction Margin record

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In Aotearoa-New Zealand, continuous records of vegetation and climate change that extend beyond the last glacial-interglacial cycle are scarce, yet are essential for understanding how terrestrial ecosystems responded to global climate transitions. The Mid-Pleistocene Transition (MPT; 1250-700 ka) represents a major shift in Earth's climate, marked by a change from 41 kyr to 100 kyr glacial-interglacial cycles and associated reorganisations in the cryosphere, oceans, and atmosphere. However, comparatively little is known about how this climate transition impacted terrestrial vegetation.

Here we present a discontinuous 1.6 Ma pollen record from the upper 510 m of the turbidite-dominated International Ocean Discovery Program core U1520D, recovered from Hikurangi Subduction Margin east of the North Island. This record captures timeslices of vegetation change before, during, and after the MPT, providing new insights into how terrestrial ecosystems responded to this global climate shift in Aotearoa-New Zealand. Our results show that prior to and during the MPT, vegetation assemblages were cooler than the last two glacial–interglacial cycles (MIS 6-5 and MIS 2-1), and there was little variability between vegetation assemblages between glacial and interglacial periods. After ~0.5 Ma, vegetation shows more pronounced variability between cold and warm vegetation assemblages, reflecting the saw-tooth glacial-interglacial cycles characteristic of the late Pleistocene. Over the last 1.6 Ma, we observe a long-term increase in temperate podocarp-hardwood forests, indicating a warming trend that contrasts with the global cooling typically associated with the late Pleistocene and the MPT.

Our findings highlight how this globally significant transition reshaped terrestrial ecosystems in the southwest Pacific and demonstrate the potential of fine-grained, turbidite-dominated sedimentary records from active marine margins to serve as exceptional archives of past vegetation and climate change.

The national scale probabilistic coseismic displacement hazard model for Aotearoa New Zealand

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An often under-appreciated hazard in tectonically active regions is the significant contribution to vertical land motions (VLM) due to coseismic displacement. In coastal regions, significant positive coseismic VLM has the potential to entirely mitigate the effects of relative sea-level rise, whilst subsidence may place regions previously considered safe at risk. To quantify the risk associated with coseismic VLM in the next 100 years, we utilise the New Zealand National Seismic Hazard Model (NSHM 2022), earthquake simulators (RSQSim) and stochastic slip models to create the Probabilistic Coseismic Displacement Hazard Model for ANZ.

Probabilities of displacement exceedances are calculated from 100,000 rupture scenarios utilising the fault geometries, rate models and epistemic uncertainties of the NSHM for crustal and Puysegur subduction interface sources. New rupture sets were generated for the Hikurangi margin using higher resolution fault geometries and stochastic slip distributions to account for artifacts that are present when using the NSHM geometries. The use of earthquake simulators allows for displacement contributions to be calculated from rate-and-state friction-based synthetic earthquake catalogues that incorporate complex multi-fault events, including combined crustal-subduction faulting. Ground motions for each rupture are modelled from dislocations in a homogenous elastic half space, allowing for individual probabilistic assessments of hazard due to uplift, subsidence, and total absolute VLM.

Initial results from the Wellington region show a 10% chance of exceeding more than 0.50 m subsidence or 0.35 m of uplift, and a 2% chance of exceeding 1m of VLM. Ongoing work looks to quantify the impact of more complex crustal fault geometries (e.g. variable dip, fault curvature) on VLM hazard. Additional future development of the hazard model will include other contributions to VLM, such as distributed seismicity, post-seismic relaxation, and slow-slip events.

Sub-surface geological mapping of the eastern Alexandra Volcanic Group, Waikato

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The Alexandra Volcanic Group (AVG; 2.74–1.60 Ma) is a 65 km-long, cross-arc chain of basaltic volcanoes located ~100 km west of the Taupō Volcanic Zone. The field hosts >120 vents of both arc and alkaline composition and is the subject of ongoing geological mapping to decipher the age, structure and tectono-magmatic origin of its bimodal volcanism. This study focuses on the AVG east of Mt. Pirongia which lies closest to the arc front and is largely buried beneath ≤200 m of Hamilton Basin sediments. Outcropping arc-type volcanoes include Pukehoua (371 m), Puketōtara, Kakepuku (449 m), Te Kawa (214 m), and Tokanui. Alkaline basalt vents are identified at Turitea (2.21 Ma) and Ngāhape (1.90 Ma). Stratigraphic interpretations from over 170 water bore logs, coal exploration records, and petroleum core logs were integrated to reconstruct the subsurface volcanic architecture. The resulting map identifies 25 volcanic vents (19 new), most of which are small-volume and correlated with the Okete Volcanic Fm. These vents follow NE-SW alignments consistent with the regional fault pattern. Buried lava fields associated with Kakepuku (2.35 Ma), Te Kawa (2.21 Ma), and the Waikeria dacite (1.99 Ma) infill basin-and-range style depressions within the Waipapa terrane. These are overlain by ring plain deposits of Pirongia Volcano (~2.5 Ma) and ignimbrites from Mangakino Caldera. The new mapping and stratigraphic constraints from this work will permit further testing of proposed, but contrasting, hypotheses (e.g. mantle upwelling via slab rollback ± tearing, hotspots or deep crustal faults) that attempt to explain the compositional, geochronological and spatial patterns of the AVG volcanoes. More broadly, the identified vent distribution at the arc–cross-arc interface may offer valuable insights into the architecture of submerged cross-arc systems, such as those within the Kermadec Arc.

Enhancing GeoNet earthquake solution quality with automated tools

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Accurate and timely earthquake solutions are critical for informing emergency response, hazard assessment, and scientific research. At GeoNet, these solutions are generated following an event and are reviewed and refined by geohazard analysts (GHAs) at the National Geohazard Monitoring Centre, first with a preliminary analysis and then a subsequent revised solution as more data becomes available.

GHAs adhere to a range of quality assurance measures, such as internal guidelines (phase and amplitude picking, event classification criteria, and escalation for specialist opinions), to provide rapid event solutions that promote consistency and transparency in decision-making. A final, post event quality assurance review of the rapid GHA event solution is conducted by the Lead Earthquake Analyst (LEA), and it provides the basis for providing feedback to GHAs.

LEA earthquake reviews are prioritised and only a subset of rapid event solutions undergo this final review. This limited oversight underscores the need for scalable tools that can support analysts while ensuring traceability across tens of thousands of solutions each year.

In response to this need, we are developing the Quality Reporting for Earthquake Solutions Tool (QREST), a lightweight web application designed to streamline quality checking. QREST automatically highlights anomalies, flags departures from guidelines, and changes between GHA and LEA event solutions to provide transparent feedback.

QREST has been designed to support three core use cases. First, it enables event-level analysis by tracking changes across the earthquake solution lifecycle, from automatic detection to LEA review, including quality of phase picks. Second, it provides operational insight by identifying inconsistent adherence to guidelines, gaps in network coverage, or areas where operating procedures may need refinement. Finally, it supports long-term monitoring, turning trends in solutions into valuable insights for maintaining expertise and driving ongoing improvement.

A new dense nodal seismic network at Ōkataina volcano, Aotearoa New Zealand

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Ōkataina caldera volcano is one of two active caldera volcanoes in Aotearoa New Zealand. Despite its most recent eruption coming from Tarawera in 1886, the area deep beneath Makatiti and Haroharo Domes (~10 km farther north) is very active: most of the earthquakes beneath Ōkataina caldera happen beneath this area; local earthquake tomography results show Vp and Vp/Vs anomalies; and magnetotelluric imaging shows a low-resistivity anomaly arrested at 1–2 km depth beneath Makatiti Dome. Here we present a new seismic network focussed on crust beneath the Makatiti and Haroharo areas with the aim of improving constraints on the location, depth, size and state of the Ōkataina's magmatic system. This magmatic system has caused multiple eruptions in the past, drives the geothermal activity we see today, and is a likely source of the next eruption from Ōkataina. The network, installed in October 2025 for 3–5 months in partnership with local Iwi Trusts, consists of ~80 nodal short-period seismometers with a 1–2 km station spacing in the main part of the network, loaned from the from the ANSIR - Research Facility for Earth Sounding national pool. We plan to use data from this dense seismic network to image the crust beneath this part of the volcano with the aim of identifying the present location, size and state of Ōkataina's active magmatic system. This in turn can be used to inform updates to physical models of the volcano, and eruption and unrest scenarios, to improve interpretation of, response to and preparation for future unrest at Ōkataina volcano.

Promoting resilience through next- and end-user engagement on volcanic ash forecast products

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All of Aotearoa New Zealand's volcanoes have the potential to erupt explosively, producing volcanic ash that can be injected into the atmosphere, dispersed by the wind, and then settle to the ground. Consequently, ashfall is the most widespread volcanic hazard, potentially impacting areas far from the source volcano. Ashfall forecast maps are critical tools for informing mitigation strategies and estimating impacts and loss; they can be issued in response to an eruption to show forecasts of the extent, amount, and timing of ashfall. However, to effectively empower communities to efficiently prepare and mobilise for potential ashfall impacts, these forecasts need to be timely, reliable, and usable.

The development of real-time Eruption Source Parameter characterisation tools aims to provide rapid (<30 minutes) and accurate estimates that can be continuously updated during an eruption. This information will enable next-users to initiate ash forecast models with accurate input parameters, and issue initial ash forecast rapidly following eruption detection. This potentially allows end-users (e.g., CDEM, infrastructure managers, community leaders) to be in a position to make faster and better-informed decisions on possible volcanic eruption impacts. By engaging with both next- and end-users to ensure a stakeholder-led focus we aim to generate fit-for-purpose content and practicable design to promote future uptake of ashfall forecast products. Our approach includes an intentional engagement strategy with methods tailored for the user-groups (next- and end-users), drawing on research on stakeholder engagement as well as previous and ongoing research globally on stakeholder needs around ashfall forecast products.

The threat of volcanic tsunami from near shore volcanoes in the Bay of Plenty, New Zealand

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Near shore volcanoes pose difficulties to quantify threats to nearby coastlines from a variety of tsunami generation mechanisms. Here we focus on flank collapse induced tsunami from Whakaari/White Island, New Zealand, and its impact on the Bay of Plenty coast. We characterise the island through multi-physics geophysical inversion and clustering algorithms to identify saturated and hydrothermally altered rock volumes that are mechanically weak. From these models we identify clusters of potential slope failures with differing characteristic safety factors and failure volumes. Several areas are identified on the northwest and southwest flanks, and range in volume from 10^5 to 10^8 m3. Characteristic volumes of rock are defined and used as sources for landslide stability models that feed into a widely used tsunami simulation code - COMCOT (Cornell Multi-grid Coupled Tsunami) for coupled landslide-tsunami simulations. We adapted COMCOT specifically to handle debris flows typical of edifice failures so that we can fully couple the subaerial and submarine dynamics. This involves a flexible nested grid algorithm that allows for two-way coupling of landslide-tsunami simulations to address differences in spatial resolution requirements and model coverages between landslide and tsunami simulations. We model the tsunami wave height and inundation at the Bay of Plenty coast, about 50+ km distant and find that tsunami generated by flank collapse are highly directional yet can attain heights that create land threats for affected areas. This work forms the basis of the first volcanic-sourced tsunami assessment for near shore New Zealand volcanoes.

Eruptive characteristics, timing, and environmental setting of the ~1 Ma Kidnappers supereruption constrained by high-resolution tephrochronology and palynology

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The Kidnappers supereruption (Mangakino volcanic centre) in the central Taupō Volcanic Zone (TVZ), New Zealand, vented >1,200 km3 of rhyolitic magma across New Zealand and the south Pacific at ~1 Ma (during the Jaramillo subchron). The eruptive deposits include a widespread phreatomagmatic fall deposit (to >2, 00 km from source) and an unusually widespread non-welded ignimbrite. The non welded nature of the Kidnappers deposits, coupled with abundant subsequent activity within the central TVZ means that exposures are destroyed or buried. Using available tephra deposits from a range of locations we reassess the timing and nature of this supereruption. Importantly, we correlate fall deposits preserved in different environments, i.e., marine, terrestrial, and lacustrine covering medial, to extremely distal areas to one another. Major and trace element data on glass shards were collected at high-resolution from multiple tephra sites to characterise any spatial or temporal variability in magma compositions. The presence of multiple glass populations within the fall deposits highlights the systematic tapping of at least five magma bodies during the eruption. Extrapolated over multiple sites this approach builds a robust model of how the Kidnappers supereruption evolved, and the extent of ash dispersal across New Zealand and the south Pacific. Further to this work, sampling of pollen at proximal and distal sites beneath the tephra, and an analysis of the eruptive deposits' dispersal, reveals the pre-eruptive geographical/environmental setting of New Zealand ~1 Ma. This work reveals a landscape susceptible to complete resetting after emplacement of the widespread ignimbrite and fall deposits.

South Island Seismology at the Speed of Light Experiment (SISSLE) — characterizing the Alpine Fault at Haast, New Zealand

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We introduce initial results from a DAS and nodal seismometer array deployed in two phases for nearly 5 months between late-February and mid-May 2023 and again in October–November 2023 on the South Island of New Zealand. The South Island Seismology at the Speed of Light Experiment (SISSLE) utilizes two lengths of telecommunication fiber: one running roughly parallel to the Alpine Fault (~18 km) and the Tasman Sea and the second that runs perpendicular to and crosses the Alpine Fault (~30 km). The Alpine Fault marks the boundary between the Australian and Pacific plates. Haast lies near a geometrically and paleoseismically distinctive segment boundary where large (~M8) earthquakes appear to preferentially nucleate and terminate on ~300-year timescales.

With the high temporal (1 kHz) and spatial (4 m) resolution, data from an iDAS unit have demonstrated improvements in the detection of weak seismic sources, including low-magnitude earthquakes diagnostic of fault activity, and distinct waveform complexity originating within the fault zone. In addition to the DAS array we also installed 24 nodal seismometers near the trace of the Alpine Fault at ~100m spacing. The dense spacing of two independent instrumentation arrays across the Alpine Fault have allowed for high-resolution imaging of the fault zone including the near-surface fault geometry and structure using cross correlations, ambient noise tomography, receiver functions and waveform modelling techniques. Our analyses to date have also focused on detection and characterization of thousands of local and regional events and are using these data, in addition to the multiple ambient noise sources, to better image the mapped fault zone and to improve our understanding the structures associated with the fault.

Assessing the public reception of the new Bay of Plenty tsunami evacuation maps

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The Bay of Plenty can expect tsunami in the future, with the potential for devastating impacts on coastal communities. Tsunami evacuation maps help educate the public about which areas are at risk. However, map creators must decide how to best visually display information for a diverse audience.

The Bay of Plenty CDEM Group released new single blue zone tsunami evacuation maps in 2023, to create a consistent region-wide approach to the tsunami hazard with simple and easy-to-understand maps. The aim of this research was to understand the public reception of these new tsunami evacuation maps.

Focus groups were conducted in three Bay of Plenty urban coastal areas and included exploring participants familiarity with the maps, scenario-based questions and feedback on map improvements.

Most participants were aware they lived in a tsunami evacuation zone with some assuming they were at risk due to proximity to the ocean. They were also aware that the blue evacuation zone represented a tsunami danger area.

When presented with different tsunami scenarios, participants generally opted to either evacuate, take precautionary measures, seek further information or additional cues or not evacuate. These decisions were shaped by a range of factors. If evacuating, most participants selected inland or elevated destinations, while a few chose sites within the evacuation zone. These decisions were influenced by many, and sometimes contradicting, variables, including the most direct route, elevated sites, avoiding isolation, avoiding crowds and various other reasons. This highlighted the importance of a diverse selection of safe locations.

Participants suggested numerous map amendments which illustrated the diverse needs across communities. Common amendments included adding evacuation routes, more safe locations and larger and more concise text. However, the development of maps must balance the needs of different communities, consider national guidelines, achieve consistency and standardisation, while being simple and easy to interpret.

Timing and eruptive characteristics of the ~349 ka Whakamaru supereruption sequence constrained by detailed analysis of tephra sites around New Zealand

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The Whakamaru supereruption from the central Taupō Volcanic Zone (TVZ), New Zealand vented >1,500 km3 of rhyolitic magma across New Zealand and the South Pacific at ~349 ka. The eruptive succession incorporates a complex sequence of welded ignimbrites in the central North Island, and correlated fall deposits of the same age (within error), documented as the Rangitawa or Kohioawa tephras, throughout New Zealand and in marine cores in the Tasman Sea and south Pacific Ocean. The inter-relationships and relative timings of these eruptive deposits remain poorly constrained but are vital to understanding the nature and potential impacts of this event. Here, we present major and trace element data from glass shards collected from multiple Rangitawa/Kohioawa tephra sites at cm-scale resolution to characterise any spatial or temporal variability in magma compositions. This work importantly correlates fall deposits preserved in different geological environments, i.e., marine, terrestrial, and lacustrine over proximal, distal, and extremely distal areas to one another. The presence of multiple glass populations within singular fall units highlights the systematic tapping of multiple magma bodies throughout the eruption. Extrapolated over multiple sites this approach aims to build a robust model of how the Whakamaru supereruption evolved, and the nature of ash dispersal across New Zealand and the South Pacific. Further to this work, post-eruptive environmental impacts are examined through high-resolution sampling of pollen at proximal and distal sites to document local changes in environment induced by the deposition of the tephra.

Palisade bubbles – Heterogeneous nucleation or something else?

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Pumice textures provide insights into pre- and syn-eruption processes occurring within magmatic systems. A distinctive feature, where bubbles form a coarsely vesicular sheath around crystals within felsic pyroclasts, is known as palisade texture. These textural features have been described in multiple studies; however, the formation and growth of palisade bubbles have little documentation, leaving many questions around what these structures show. Are they being formed through heterogeneous nucleation where bubbles nucleate on mm-scale quartz, feldspar and pyroxene phenocrysts, or are they something else? If they show heterogeneous nucleation this challenges the current understandings around bubble nucleation, where experimental bubbles are seen to typically only nucleate on small Fe-Ti oxide crystals. Using Micro-Computed Tomography and Scanning Electron Microprobe analysis we investigated 150 rhyolitic, dacitic and phonolitic pyroclasts from New Zealand, Germany, the USA and the Kermadec Arc to document the frequency and natural variability of the internal bubble structures to develop a classification guide. Results of this study show 66% of pumice clasts contained palisade bubbles, situated around individual or clustered phenocrysts. These structures have thick bubble walls around the outer edge, with small clusters (10's of bubbles) being dominated by spherical to subspherical bubbles, while larger (<100 bubbles), exhibit more deformation and elongation. Palisade bubbles often pull apart the crystals that they surround, forming augen-like structures of thin glass films, and distorting the surrounding groundmass. Results indicate that early bubble growth was initiated deeper in the system around felsic phenocrysts, implying volatile saturation within the system, either stably within the magma chamber or during the earliest stages of magma rise. Subsequent decompression of the supersaturated magma caused the rapid expansion of these bubbles, prior to runaway nucleation within the groundmass glass. Results from this study will contribute to a better understanding of bubble nucleation processes within felsic magmatic systems.

Textural variations in pyroclasts of the 232 CE Taupō eruption – a three-dimensional approach

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The Taupō 232 ± 10 CE eruption involved six episodes which generated three phreatomagmatic ash deposits (units Y1, Y3, Y4), two plinian fall deposits (units Y2, Y5) and a widespread ignimbrite (unit Y6) from a compositionally uniform magma. Microtextural imaging of clasts in these deposits reveal a wide variety of textures associated with complex bubble nucleation and growth histories that are independent of the uniform magma composition. A 3D investigation of textural characteristics of pyroclasts in the eruptive sequence will further the understanding of the pre- and syn-eruptive processes that can be related to the observed changes in eruption style, particularly between 'dry' (plinian) and 'wet' (phreatomagmatic) activity. The Micro-Computed Tomography beamline at the Australian Synchrotron was therefore utilised to explore pumice textures that reflected the evolution of magma:water interaction with varying magmatic processes (e.g. eruption rate) during all episodes of the Taupō eruption. Results indicate that the pumice clasts (between 0.2–1.2 g/cm^3) from all units have vesicularities of 50–92 % and have vesicle number densities from 1.4–7.6 x 10^{15} cm-^{3}. In the pyroclasts, five textural types are defined: 1) micro-vesicular; 2) macro-vesicular; 3) foamy/fibrous; 4) transitional A, intermediate between types 1 and 2; and 5) transitional B, intermediate between types 2 and 3. Large variations in bubble shapes, from spherical (sphericity = 1) to elongate and tabular (sphericity <1), are observed throughout the pumice types (sphericity range of 0.011–1). Type 1 pumice clasts typically are devoid of sheared vesicles while types 2-5 display varying degrees of shear strain. Units Y5 and Y6 show the largest variations in textural features in the sequence while Y4 is dominated by dense type 1 pumices. Using these pyroclast textural data, we highlight the complexities in magmatic and conduit processes driving this large multiphase event.

Illuminating the deep structure of the Marlborough Fault System using microseismicity

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The Marlborough Fault System connects the transpressive Alpine Fault, through the northern South Island, to the Hikurangi subduction zone. This complex network of interconnected faults played a key role in the 2016 Kaikōura earthquake, which ruptured at least 21 separate surface faults. How these faults connect at depth remains poorly understood but likely influences both the likelihood of single-event multi-fault earthquakes and interactions between faults in earthquake "cascades." Microseismicity provides critical insights into fault geometry and conditions at seismogenic depths; however, accurate detection and analysis in such a complex setting require dense observations. We present initial results from the "Marlborough Observatory Researching Interconnectedness beneath the Alps" (MORIA) array, which was deployed in March 2025 and is expected to operate for at least two years. MORIA comprises 47 broadband seismometers across the Marlborough region, spaced ~10 km apart. Data from a combined network of 151 stations—MORIA (47), DPRI (25 short-period), and GeoNet (79 short-period and broadband)—were analysed.

To test advanced computational methods for earthquake cataloguing, we produced a seismic catalogue spanning pre-MORIA to October 2025. Over 1700 earthquakes per month are detected within the study area, a 30% increase over the GeoNet catalogue. The catalogue, developed using data from MORIA and adjacent networks, will underpin a detailed investigation of seismicity in the region between the Alpine Fault and the Hikurangi Subduction Zone, with the aim of developing a 3D fault model as part of the Endeavour Funded Ngā Ngaru Wakapuke Programme.

Early Results on topographic amplification in submarine canyons: insights from OBS deployment in the MAWACAAP Project (SO310)

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The MAWACAAP Project (SO310) investigates the geomorphic evolution and geohazard potential of submarine canyons on both active and passive margins, with a focus on Pegasus and Palliser Canyons near New Zealand's Cook Strait. This international collaboration between GEOMAR, University of Kiel, GSI (Israel), NIWA, and GNS Science is conducting a comparative analysis of canyon systems across tectonic settings to better constrain sediment instability, earthquake amplification, and failure processes.

A key element of the SO310 voyage aboard R/V SONNE was a 23-day deployment of eight Ocean Bottom Seismometers (OBS, 4.5 Hz 3-component) in Palliser Canyon. Numerous local earthquakes occurred during this period, generating a unique dataset for studying topographic amplification effects through both direct observations and numerical experiments.

We present early results from the OBS deployment and boundary-element simulations that quantify how canyon morphology may focus or enhance seismic ground motion. The 3D simulations discretize seafloor topography into surface elements, each represented by a Green's function response to input ground motion. Calibration is underway using amplitude variations observed in seismograms recorded during the deployment.

By combining seismological observations, high-resolution bathymetry, and geological context, these early results provide new insights into how submarine canyon geometry and shallow structure modulate seismic shaking. This has direct implications for slope stability, submarine landslide initiation, tsunami generation, and offshore infrastructure risk.

A history of faulting in Tāmaki Makaurau-Auckland from the Miocene to present day

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Although not considered as seismically hazardous as other regions of the North Island (e.g., Taupō Volcanic Zone, North Island Dextral Fault Belt), Tāmaki Makaurau-Auckland contains a rich and ongoing record of fault activity recorded in geological, geomorphic and geophysical datasets. Here we present a compilation of the Miocene to Present structural fabric of the Auckland region, highlighting the region's importance for understanding the tectonic history of the North Island as well as earthquake and volcanic hazards in our country's most populous city. A pervasive pattern of NE- and NW-oriented faults is observed in lithologies from the Mesozoic to Present, supporting ongoing reactivation of inherited basement weaknesses. In addition, Miocene lithologies (Waitākere and Waitematā Groups) show prominent NE-trending extensional structures (faults, joints, dikes and veins), suggesting a phase of NW-directed Miocene extension, with these structures representing a potential continuation of the Taranaki Basin. Similarly, reverse faults observed in Waitematā Group rocks may record an early phase of Miocene shortening like that observed in the Taranaki Basin. Evaluations of borehole data in Central Auckland have identified at least 10 concealed post-Miocene faults, with even more faults recognised in South Auckland (e.g., Drury, Wairoa, Pukekohe, and Mangatangi Faults); however, the fault slip histories and recurrence intervals on these faults are largely unknown, yet critical to our understanding of the seismic hazard in Auckland. Recent investigations of the Mangatangi Fault provide evidence for surface-rupturing earthquakes in South Auckland over the past 20,000 years, with recurrence intervals on the order of 10^4 years for some faults. Given this fault network's close proximity to New Zealand's most populous city, we recommend that future seismic hazard assessments place greater emphasis on reconstructing the earthquake histories of local fault structures in both Central and South Auckland.

Earthquakes and citizen science: understanding human behaviour through GeoNet Felt Detailed Reports

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Felt Reports serve as a critical data source for assessing the perceived intensity of earthquakes. In Aotearoa New Zealand, GeoNet collects these reports through two mechanisms: the Felt Rapid and the more comprehensive Felt Detailed surveys. While the primary purpose of these reports is to inform scientific understanding of shaking intensity, the Felt Detailed Reports additionally capture individual behavioural responses and emotional reactions during earthquakes. The Felt Detailed Reports, submitted in the immediate aftermath of an earthquake, offer valuable insight into perceived shaking, emotional states, and protective actions.

This research utilises Felt Detailed data from seven significant earthquakes occurring between 2016 and 2024 to examine the behavioural responses of individuals in Aotearoa New Zealand. Approximately 16,000 survey responses were analysed using quantitative methods to identify behavioural patterns and assess the relationships between behavioural and emotional reactions and a range of influencing variables, including perceived intensity, felt duration, and demographic characteristics.

The analysis revealed a significant association between behavioural responses and perceived shaking intensity. As intensity increased, there was a marked shift from passive to active behavioural responses. While recommended protective actions—such as "Drop, Cover, and Hold"—became more prevalent at higher intensity levels, outdated actions such as "moving to a doorway" and "immediate evacuation" were also frequently reported. Two key observations emerged from the analysis: i) many individuals hesitated to take protective action until the shaking became severe, by which time it may have been too late to act safely, and ii) despite ongoing efforts to promote earthquake safety education, knowledge, and application of recommended protective behaviours remain inadequate. Further investigation is necessary to better understand the complex behavioural patterns observed and examine additional contributing factors. This will facilitate enhanced understanding of how people experience and respond, and how these responses are influenced by the physical characteristics of earthquakes.

Earthquake and tsunami risk communication with culturally and linguistically diverse communities in New Zealand

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New Zealand's Culturally and Linguistically Diverse (CALD) communities, particularly overseas-born migrants, face unique challenges in preparedness for and response to natural hazards such as earthquakes and tsunamis. Differences in hazard experiences, socio-cultural backgrounds, and social learning influence how these communities access, understand, and respond to risk communication, including preparedness messages, warnings, and advisories. Factors such as language barriers, lack of culturally appropriate guidelines, limited social networks, and systemic marginalization reduce their ability to adopt preparedness actions. At the same time, while CALD communities possess valuable skills and resources, a lack of awareness of these assets often leads to them being overlooked in practice. As a result, CALD communities are more likely to be disproportionately impacted by natural hazards. Yet, limited knowledge exists about their needs, existing resources, and the support required for effective communication on earthquakes and tsunamis.

In this context, this paper draws on qualitative data from two urban areas in New Zealand with high CALD populations to examine how CALD communities have accessed, understood, and responded to earthquake and tsunami communication over the past decade. The study also identifies needs and gaps, and explores how community resources and skills can be better leveraged to strengthen hazard communication. It focuses on three groups: short-term residents (e.g., tourists, working holiday visa holders), medium-term residents (e.g., work visa holders), and long-term residents (permanent migrants). The findings provide insights into improving communication with CALD communities during disasters.

Costal and Hydrology Laboratory at the University of Auckland

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Electron Probe Microanalyser at the University of Auckland

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The School of Environment Electron Probe Microanalyser Laboratory is equipped with the JEOL JXA-8530F Plus Hyperprobe Field-Emission Electron Probe Microanalyser (FE-EPMA). This instrument features an In-Lens Schottky field emission electron gun, allowing for higher throughput, stability, and spatial resolution than conventional micropobes. The JEOL JXA-8530F's bib-destructive, high-precision analysis, can provide the quantitative elemental blueprint of most solid materials at the micron and sub-micron scale, for all academic, industrial and professionals needs.

Fault growth models from historical earthquakes and active faults in New Zealand

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Faults in the brittle upper crust are thought to primarily grow due to repeated earthquakes. To better understand fault growth, we analyze the geometry of fault traces and displacements for individual earthquakes (since 1840 AD) and over millions of years on New Zealand active faults. The active faults studied are from connected networks with a range of orientations, lengths (1–200 km), displacement rates (0.1–27 mm/yr) and slip types. Our data indicate that individual earthquakes produce slip on multiple faults with variable sizes, orientations and slip types; in some cases, these earthquakes rupture cross tectonic domain boundaries. Earthquakes can produce partial or complete rupture of bedrock faults and show little evidence of tip propagation, characteristics most closely resembling the constant-length fault growth model, where growth is primarily achieved by increases in cumulative slip. Earthquake slip profiles display a range of shapes with one or more maxima. High gradients along faults and approaching fault tips reflect coseismic slip transfer to nearby faults. These high slip gradients are consistent with stress interactions and kinematic coherence between faults during individual earthquakes (i.e., timescales of seconds to minutes). Coseismic increments of slip increase with rupture length and are described by a power function of ~0.5, while the power function for cumulative displacement and final length is ≥1. For constant fault lengths, an important consequence of these divergent power functions is that larger faults generally accrue their finite displacements in more earthquakes than smaller faults. The increase in earthquake number with fault size is achieved by a combination of shorter recurrence intervals and longer faulting histories for larger faults. We believe that our New Zealand observations have global application.

Multiple canyon-sources of organic carbon in the 2016 Kaikōura event bed

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Submarine canyons are conduits for the transfer of megatonnes of sediment and organic carbon (OC) into the ocean, nourishing deep-sea ecosystems and contributing to the global carbon cycle through OC burial and sequestration. Tracking lateral OC transport through multiple submarine canyon systems is complicated by the need to differentiate episodic depositional events from background processes and to identify sources, composition and ages of marine and terrestrial organic matter. Sediment samples were acquired from submarine canyons, the Hikurangi Channel and adjacent levees across the southern Hikurangi subduction margin and Pegasus Basin. We applied parallel ramped pyrolysis oxidation-and pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS), radiocarbon dating and stable isotope analyses to track OC sources and ages in the 2016 Kaikōura earthquake-triggered turbidites. Initial results reveal the regional composition of organic matter in the Kaikōura Event Bed (KEB) is uniform, with higher marine than terrestrial organic matter (OM) contributions based on Py-GC-MS data. The majority, however, comprises refractory OM, i.e., largely degraded and thermally mature OM that cannot be confidently attributed to distinct sources. OC ages are variable, with increases in sediment age correlating to textural coarsening, and higher and lower amounts of refractory and marine OM contributions, respectively. Repeat sampling over five years at one site on the Hikurangi Channel levee suggests a small progressive increase of refractory products with time in the KEB. First-order modelling of the KEB distribution across the Pegasus Basin suggests that ~5 Mt OC was retained within the Hikurangi Channel, and ~19 Mt OC deposited on the surrounding levees. A significant amount of OC was delivered laterally via the Cook Strait canyons. These data re-emphasise the large contribution of earthquake-triggered events and turbidity flows in the transport, remobilisation, dispersal, burial and sequestration of OC in the deep-sea, and their significance to the modulation of the long-term carbon cycle.

Earthquake swarm in 2025 and seismic velocity structure in the Abu monogenic volcanic group, southwestern Japan

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Introduction

New earthquake swarm activity in northern Yamaguchi Prefecture, southwest Japan, began in February 2025. The swarm occurred beneath the Abu Monogenetic Volcanic Group (e.g., Kakibuchi et al., 2000; Koyaguchi, 1986). There are about 40 monogenic volcanoes within an area of 400 km^2. The volcanic activity began 2.0 Ma; the early phase continued for 0.4 Ma, and the late phase resumed at 0.8 Ma. The lavas are classified into alkali basalt in the early phase, and calc-alkali andesite was also found in the late phase (e.g., Kakibuchi et al., 2000). The alkali basalt in the early phase is thought to have originated from the mantle diapir, and the calc-alkali andesite was thought to be a mixture of the melting of the crust.

Generally, the crustal seismicity is limited to above the brittle-ductile transition at a depth of about 15-20km. In some areas, deep seismicity, including low-frequency earthquakes in the lower crust, can be seen (e.g., Ohmi et al., 2004).

This deep seismic swarm could be related to the fluid. The seismic velocity structure has information related to the fluid, i.e., a low velocity as a large amount of fluid and a high Vp/Vs as a high fluid pressure. Thus, we investigate the seismic velocity structure in and around the focal area of the deep seismic swarm.

Method

The double-difference tomography method was used for the seismic wave velocity structure (Zhang and Thurber, 2003, 2006); 2282 earthquakes from October 2000 to May 31st, 2025, were used in the analysis.

Result

High Vp/Vs and low Vs areas can be observed at a depth of approximately 25 km in the vicinity of the seismic activity zone.

The presence of these areas suggests a relationship between the seismic activity/crustal deformation and fluids, which are considered to be the cause.

Can ridge rents in Arthur's Pass National Park record past large earthquakes?

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The 1929 Mw 7.0 Arthur's Pass earthquake was the largest recorded earthquake in Aotearoa New Zealand since the 1888 North Canterbury earthquake. It received little study at the time, due to its remote alpine location and because it was overshadowed by the destructive Mw 7.3 Buller earthquake three months later. Subsequent work identified coseismic landslides and proposed that the 1929 Arthur's Pass earthquake ruptured the newly mapped Poulter Fault. The recent release of new airborne lidar data enables a more detailed assessment of possible coseismic deformation associated with the 1929 Arthur's Pass earthquake. Preliminary mapping has revealed numerous short (<1–2 km) uphill-facing scarps in higher elevation parts of mountain ranges and no obvious through-going continuous fault trace. These scarps have apparent normal slip that are consistent with ridge rents (also referred to as sackungen and antislope scarps). Worldwide, the role of strong earthquake shaking in the formation and/or reactivation of ridge rents is unclear. However, the high density of these scarps near the modelled epicentre and along the zone of coseismic landsliding suggests they may be related to the 1929 Arthur's Pass earthquake. To test this, we plan to extract cores from ridge-top tarns adjacent to scarps and date organic material to help constrain the timing of their formation. We will combine these field data with high-resolution ground motion simulations from several plausible earthquake sources, to test whether ridge rents can help constrain the earthquake source. On- and off-fault paleoseismology techniques have been successfully applied in Aotearoa New Zealand, but dating material from ridge rents has not yet been widely tested. If successful, this methodology will provide a widespread record of strong ground motions for a poorly understood earthquake. Additionally, it will provide another tool to investigate earthquake behaviour in bedrock fault settings, inaccessible through traditional paleoseismic techniques.

The UC Earth Science Garden: bringing the field to the classroom

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Spatial skills are essential for success in STEM, particularly in the geosciences, where they underpin core competencies. However, teaching these skills effectively remains a major challenge. This work presents part of an innovative pedagogical approach that integrates cutting-edge digital tools with authentic, tactile learning experiences to enhance spatial reasoning and engagement in university geology education. Central to this strategy is the UC Earth Science Garden - New Zealand's first comprehensive map-based teaching rock garden and one of only three at this scale worldwide. Located on the University of Canterbury campus and officially opened in April 2025, the Earth Science Garden features over 200 hand-selected rocks representing 15 key South Island lithologies. Arranged to mirror the geology of Te Waipounamu, it includes key features such as a schist-based Southern Alps, offset dunite at the Alpine Fault, marine fossil-bearing concretions, and a mini volcano representing Banks Peninsula. This living laboratory incorporates native flora tied to rock types and regional ecology, offering an interdisciplinary and immersive learning environment.

Pedagogically, the garden addresses three major challenges: limited field hours, unequal access due to financial or physical barriers, and the difficulty of connecting textbook diagrams to real-world geology. Situated minutes from lecture theatres, the garden enables integrated, hands-on exercises and self-directed learning. It provides 24/7 access and an inclusive fieldwork experience, especially for students with mobility or time constraints. As a result, more time during field trips can be devoted to deeper analysis and interpretation.

The garden also serves as a public outreach resource, with potential to engage schools and the wider community, and offers opportunities to incorporate regional pūrākau, enriching students' understanding of Aotearoa New Zealand's geological and cultural landscapes. This approach reimagines geoscience education as more accessible, engaging, and relevant - developing future-ready graduates with theoretical, technical and cultural competence.

Assessing the tsunami hazard from sub-aerial landslides on Whakaari / White Island

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Whakaari (White Island) is a volcanic island in the Bay of Plenty, which has been the focus of extensive geophysical surveys under the Beneath The Waves Endeavour programme. The surface of Whakaari shows evidence of substantial past landslides, and potential future ones. Many of these landslides have, or potentially could, descend into the sea in such a way that a tsunami is generated. Given the proximity of the island to the coastal population centers of the Bay of Plenty, it is important to understand the potential impacts. Using the COMCOT tsunami modelling software we have developed a capability for modelling the landslide descent, and subsequent tsunami generation, propagation and inundation. We present a sensitivity study, illustrating how the tsunami threat to the Bay of Plenty coastline is related to the orientation of the failure surface slope, the landslide volume, initial elevation, aspect ratio, and friction parameters. An ensemble of potential failure scenarios has been developed using multiphysics models of airborne electromagnetic, magnetic, and gravity data coupled with limit equilibrium modelling of landslide susceptibility. Future work will combine these multiphysics based scenario results with estimates of landslide likelihood from earthquake and rainfall triggers for the purpose of quantitative inundation hazard assessment at the coast.

The NZP&M Geodata Catalogue – three years on: growth, pipelines, lessons learnt and the future

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It has been nearly three years since the launch of the NZP&M Geodata Catalogue (GDC). How has it gone? What have we learned about the reality of dissemination of open data, and using open-source software? How much use is the system getting and where are the users from? Is there more that we could be doing?

Come along for an update on the GDC and thinking for future work that will improve it.

Space weather vulnerabilities in the North Island, Aotearoa New Zealand

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When considering natural hazards on Earth, the most immediate examples that come to mind are earthquakes, tsunamis, landslides, volcanic eruptions, and cyclones. However, modern society has become increasingly dependent on technology and electricity-based infrastructure and geomagnetic storms are emerging as a relevant and disruptive natural hazard. These space weather events, driven by solar activity, have the capacity to produce geomagnetically induced currents (GIC) that interfere with power grids, communication networks, satellite operations, and other critical technologies.

As part of the Solar Tsunamis project, a university, government, and industry led endeavour to assess space weather impact in Aotearoa New Zealand, a regional scale magnetotelluric (MT) campaign was deployed to map how the ground responds to space weather storms. These measurements are used to improve storm simulations that identify where hazards are most likely to occur in the power grid. Results show that the GIC hotspots are driven by a combination of parameters that include the (1) magnetic source field, (2) earth conductivity structure, and (3) grid configuration. By adjusting these parameters across multiple storm scenarios, we present why certain areas are more vulnerable than others.

Beyond the façade of monotony: geochemical signatures of a heterogeneous magmatic mush reservoir

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Eruptions of crystal-rich monotonous intermediate ignimbrites eject large volumes of pyroclastic material that are generally interpreted as remobilized components of the underlying magma mush system. While common globally, the only known example in Aotearoa New Zealand is the Waiteariki Ignimbrite, which erupted from the Omanawa Caldera in the Tauranga Volcanic Centre (TgaVC) around 2.1 Ma during the early period of the Taupō Volcanic Zone (TVZ).

The Waiteariki supereruption evacuated ~870 ± 270 km³ of crystal-rich (~37%), rhyodacite (~71 wt.% SiO_2) magma, characterized by: (1) a mineral assemblage comprising plagioclase, hornblende, orthopyroxene and quartz; (2) restricted ranges in whole-rock geochemistry; and (3) an absence of systematic compositional or up-section geochemical gradients throughout the ignimbrite. Despite this apparent homogeneity, changes in fiamme mineralogy, broad ranges in mineral chemistry and subtle variations in glass composition provide evidence for open-system magmatic processes and a vertically extensive, compositionally heterogeneous magma reservoir comprising contiguous and laterally juxtaposed mush bodies.

Magmatic conditions for the Waiteariki Ignimbrite are estimated using independent geothermobarometer models, including crystal-melt equilibria (plag-liq, opx-liq) or crystal-only thermobarometers (cpx; Al-in-hornblende). These models indicate bimodal storage temperatures ranging from 740-840°C and 900-990°C (ave. 790°C, and 950°C, respectively), with corresponding pressure estimates of <50-150 MPa. Such pressures are consistent with shallow, upper-crustal storage (2-6 km), comparable to those inferred for other rhyolitic systems within the TVZ.

Magmatic evolution of Whakaari volcano: insights from marine cores

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Whakaari (White Island) is historically Aotearoa's most active volcano, yet the evolution, drivers, and longer-term cyclicity of its magmatic system remain poorly constrained. Exposed subaerial stratigraphy has been largely destroyed by hydrothermal alteration, lacks a robust temporal framework, and is biased towards effusive eruptions. This limits our ability to contextualise historic and future activity. We present new geochemical and petrological data from radiocarbon-dated marine tephra units in Whakaari's previously unstudied offshore explosive record, to constrain the magmatic evolution and provide a temporal framework for prehistoric eruptive activity. During the TAN2315 voyage, marine sediment cores up to 5.4 m long were collected around the island. Chemical analyses were conducted on 13 macroscopic tephra units from five of these cores. Major element compositions of mineral cores and rims were measured by Electron Probe Microanalysis, while trace element and Sr and Pb isotope compositions of host melts were measured by Inductively Coupled Plasma Mass Spectrometry and Thermal Ionisation Mass Spectrometry, respectively. Normally zoned plagioclase (An_{55}-An_{85}) and variably zoned pyroxenes dominate all units, while normally zoned olivine (Fo_{84}-Fo_{92}) is a minor phase in three units. Groundmass is texturally bimodal, consisting of a co-existing black, microlite-rich glass and a brown, microlite-poor glass. One magmatic eruption episode recorded in a proximal core comprises three successive juvenile-rich eruptions with progressively decreasing SiO_2 contents from 68 to 64 wt.% and increasing pyroxene rim Mg# from 67 to 77. This is followed by a lithic-dominated eruption, interpreted as a fresh magma batch breaking the hydrothermal vent seal, initiating a new episode of magmatic activity. We also identify an unknown volcanic source proximal to Whakaari, with rhyolitic products identified in several cores north of the island. Our framework supports interpretations that Whakaari's magmatic system and eruptive behaviour vary in response to deep magma recharge, providing improved constraints for future activity.

Mapping neotectonic stress pattern of New Zealand

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New Zealand, located at the boundary between the Australian and Pacific plates, provides a natural laboratory for investigating present-day crustal stress. In this study, we present a completely revised stress dataset for New Zealand, integrating six established methods: 290 borehole records, 3,833 earthquake focal mechanisms, 280 formal inversions, and 72 orientations from young geological structures.

The resulting crustal stress map reveals a dominant ESE–WNW orientation of the maximum horizontal stress (SHmax) across much of the South Island. This orientation intersects major strike-slip faults at a high angle, suggesting that these plate-boundary structures are mechanically weak. In contrast, the North Island displays a more variable stress field, strongly influenced by Pacific Plate subduction along the Hikurangi Margin. In the Taranaki Basin, the SHmax is oriented ENE–WSW, consistent with NW–SE extension inferred from geological evidence. The average ENE–WSW SHmax orientation is subparallel to both the subduction trench and the strike of the subducting slab (N50°E) beneath the central western North Island. We therefore suggest that slab geometry and slab rollback are the key controls on crustal stress in the Taranaki Basin. In the Hikurangi Subduction Zone, shallow and deep stress orientations both fluctuate, whereas in the Taupo Rift Zone, shallow and deep stresses are strikingly different, pointing to a sharp mechanical decoupling.

We further compare the present-day stress field with neotectonic fault zones from the Community Fault Model across 28 tectonic domains. Most domains show strong agreement between stress orientation, fault geometry, and faulting style, confirming the activity of mapped faults. However, there are some notable inconsistencies, such as in the southeastern South Island. These observations can be used in the assessment of the fault reactivation potential in the context of physics-based seismic hazard assessment

Pluton Map characterisation of Aotearoa New Zealand's intrusive rocks

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The completed Pluton Map project has characterised more than 380 plutons and intrusive rock occurrences in terms of their properties around onshore and offshore Aotearoa New Zealand. Key samples have been identified that represent these and 291 are named plutons with a mapped extent. Most of the named plutons have more than 50 measured properties and more than 15 descriptive or interpreted classifications, such as dominant mafic and aluminous mineralogy, suite and batholith affiliation, and age dating parameters. The measured properties include 321 with XRF whole rock major element geochemistry (and >300 with at least 15 XRF trace element concentrations), 289 with U-Pb zircon or monazite dates, and 255 with feldspar $\delta^{18}O$ isotope ratios. Calculated element values and ratios commonly used for pluton discrimination include Sr/Y, K/Rb, ASI, MALI and eU.
Pluton property data have been linked to mapped pluton geometries. The pluton extents have been interpolated and extrapolated where they are obscured by Quaternary sediment, lakes, and near-shore ocean. Thirty-four new plutons have been identified, mostly in the Tasman and West Coast regions, utilising existing observations, interpretation of recent aeromagnetic data, and new geochemistry and geochronology.

The Pluton Map project has been summarised in an Atlas of Pluton Properties comprising 51 maps of colour-symbolised classifications and measured properties. The pre-Alpine Fault (circa Oligocene) restoration of the atlas map shows pluton property continuity and trends between Tasman-West Coast and Fiordland across what was a continuous Gondwana margin.

Availing geoscience with national and international data standards

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In a world awash with geoscience datasets, many high-quality and many not, there are challenges in discovering useful and usable data. For geoscience data generators and providers there are challenges reaching their audiences and ensuring their data are used. Geoscience data standards can help both the user and the provider; these standards can provide discoverability, explanation, consistency and guidance.

Geoscience information standards are themselves not always easy to find, understand and apply. International geoscience terminology standards such as the vocabularies published by the Commission for the Management and Application of Geoscience Information (CGI) are designed for global applicability but many of the vocabulary terms are not used by some jurisdictions or in some regions. Other key terms may be missing and consequently vocabularies are commonly developed for more local purposes, thus adding to the plethora of standards. CGI has also been instrumental in developing logical data models for geological and earth resource information and these models enable transfer and synthesis of geoscience information.

The value of using broadly sanctioned and adopted information standards across all science domains is widely appreciated. Discovering standards is not just a geoscience domain issue – many international science data groups struggle to promote their standards. A new initiative from the International Science Council's Committee on Data (CODATA) has been proposed to investigate the viability of a global science data standards register. Registered standards would be supported by metadata describing their function and applicability. Registration of standards could also act as a filtering process that would only lodge information on behalf of suitably accredited organisations, thereby providing assurance of quality – trusted standards applied to and complementing trusted data.

Toward lightweight on-site earthquake early warning: evaluating the Mamba state-space model

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Developing effective Earthquake Early Warning (EEW) systems remains a critical challenge in seismology. Building on QuakeNetNZ, a lightweight P-wave detection model with over 97% accuracy, currently deployed on CRISiSLab Raspberry Shake sensors for continuous real-time detection, we are extending this capability toward full on-site EEW functionality. The key next step is estimating the intensity of the incoming S-wave from the initial P-wave signal, enabling rapid alerts directly at the sensor level.

While models such as Transformers have achieved high performance in seismic detection and intensity estimation, their computational demands make them impractical for deployment on low-power edge devices. To address this, we are investigating the potential of Mamba, a recently developed selective state-space model (SSM) designed for efficient sequence processing. With linear scalability in both training and inference, Mamba is well-suited to handle continuous seismic waveform streams in real time.

Our ongoing work explores Mamba's effectiveness in processing P-wave triggers and predicting subsequent S-wave intensity. We are evaluating its ability to capture critical signal features through its selective scan mechanism, while maintaining the lightweight efficiency required for edge deployment. Preliminary results suggest that Mamba can provide both accuracy and scalability, offering a promising path toward reliable single-station EEW. This research aims to demonstrate that Mamba-based models can form the basis of next-generation on-site EEW systems, enabling faster and more efficient seismic monitoring across distributed sensor networks.

Bryozoan time travel to the tropical Lower Devonian Reefton Group

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Palaeontology is a portal to time travel, perhaps to times when we were in warm equatorial climates that allows all of us to fully understand how dynamic our history has been and understand past ecosystems. But what are the creatures that were in our oceans? We have records of corals, stromatoporoid sponges, fish and numerous invertebrates; however, bryozoans, a group of colonial invertebrates with a long fossil history that are ecosystem formers in the modern oceans around Aotearoa are poorly studied in our Devonian rocks. The Lower Devonian Reefton Group comprises mudstones, sandstones and limestones deposited on the Gondwanan margin at low latitudes, with a reef framestone of stromatoporoid sponges and corals in the Lankey Limestone. Encrusting and massive trepostome and cystoporate bryozoan colonies are present and may encrust the much larger corals and stromatoporoids. Recent work on the muddy limestones between the coral and stromatoporoid mounds in the Lankey Limestone has revealed numerous new species distributed across several orders: Fenestrata (at least four taxa), Cryptostomata (at least one taxon), Trepostomata (several taxa) and Cystoporata (at least three taxa). Colonies are generally small and fragmentary; however, a diverse fauna will be revealed with further work that can begin to reconstruct a clearer picture of life in the Devonian of Aotearoa and the part that bryozoans played.

A geostatistically enhanced random forest model for high-accuracy seismic property estimation

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Reliable property modeling is crucial for the development of Earth resources and underground storage. Leveraging seismic data to generate three-dimensional secondary variables as trends in geostatistical simulations can significantly improve model accuracy. However, these seismic-integrated models are still vulnerable to uncertainty due to inherent limitations in seismic data, such as resolution, as well as the cumulative effects of signal processing and attribute computation. Here, we propose a kriging-enhanced random forest model designed for high-accuracy estimation of reservoir properties based on seismic attributes. We applied our methodology to predict porosity in a late Albian–early Turonian shallow-marine carbonate reservoir characterized by a complex diagenetic history. Upon the extraction of the seismic attributes, we used them, along with porosity well logs, as inputs for the kriging-enhanced random forest model. This model calculates the mean of decision trees through kriging estimation rather than the typical averaging method. This approach leverages the ensemble learning capabilities of random forests to effectively handle limited training data, while incorporating the ability of kriging to account for spatial correlation. To evaluate the effectiveness of our approach, we compared it with a deep neural network, a kriging-enhanced deep neural network, and a standard random forest model. The porosity generated by the kriging-enhanced random forest showed a stronger correlation with actual porosity values in blind wells than the porosity produced by other methods. Moreover, our approach successfully reproduced complex geological heterogeneities, such as channels with various shapes and differing reservoir qualities across different stratigraphic sequences. Therefore, this porosity cube can serve as a reliable 3D secondary variable for further geostatistical simulations.

Gravity flow processes during submarine canyon flushing events

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Millions of tons of sediment can be transported through submarine canyons during infrequent, high magnitude flushing events, transporting sediment, nutrients and contaminants into the deep ocean. Direct observations of individual flushing events remain difficult due to their destructive nature and infrequency. In this study, we present high-resolution multibeam bathymetry acquired in October 2020 using an Autonomous Underwater Vehicle (AUV), which allowed us to reconstruct changes in flow dynamics during the 2016 Kaikōura Canyon flushing event.

Our detailed geomorphological analysis reveals grooves and erosive scours in the mid-canyon that coexist with coarse-grained depositional bedforms, indicating a transition from concentrated debris flow to dilute turbidity current. From the mid- to lower canyon, the seafloor is covered by gravel waves that vary in size, crest shape, and orientation, reflecting shifts in turbidity current dynamics, including changes in threshold shear stress and flow acceleration both across and down canyon. These findings provide new insights into the processes shaping nearshore, bedrock-incising submarine canyons and advance our understanding of sediment transport and erosion in similar settings worldwide.

Sediment resuspension during anchoring operations

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Routine vessel anchoring impacts the seabed with direct and indirect implications for the health of the shallow marine environment. However, the extent of physical impacts such as disturbance of seabed structure and modification of local water column turbidity are yet to be quantified.
Here we present the results of a field experiment measuring the real-time impacts of a 24-h anchoring event in Te Whanganui-a-Tara, Wellington Harbour, Aotearoa-New Zealand. We collected turbidity measurements from the bow of the ship on anchor and detected increased water column turbidity caused by anchor emplacement and recovery. These observations were coupled with i) a grid of vertical turbidity profiles covering the region adjacent to the anchoring site during the event; and ii) turbidity and current measurements from two moorings deployed next to the anchoring site. Our study provides the first in-situ observations constraining the spatial and temporal extent of the resuspension plumes and quantifying the sediment concentration released during an anchoring event.

This study sheds light on the importance to quantify the disturbance of the seafloor during vessel manoeuvres, to assess the potential risk of anchoring for shallow marine environments such as decreases in light penetration due to increased water turbidity and resuspension of contaminants.

Mantle deformation in northwestern North Island, New Zealand

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We use new on- and off-shore seismic stations to make teleseismic shear wave splitting measurements to characterise the anisotropic structure of northwestern North Island, New Zealand, and present an interpretation of upper mantle deformation for the region. Measurements of shear wave splitting are arguably the most robust method to map seismic anisotropy in the Earth's upper mantle. Seismic anisotropy, the directional dependence of seismic wave velocity, reflects past tectonic deformation of the lithosphere, or present asthenospheric flow, and is therefore a useful tool to observe upper mantle deformation.

Previous shear wave splitting studies in the region were limited by a low density of the seismic network, and lack of focus on the region. This study incorporates 26 permanent GeoNet and 38 temporary seismic stations, 52 of which were deployed after December 2022, which represents a significant increase from previous work.

We use the SplitRacer and SplitRacerAUTO MATLAB code to obtain 435 single splitting measurements, of which 403 are 'null-measurements', showing no splitting. We observe a large region of apparent isotropy, surrounded by a parabolic U shape in the fast axis orientation which opens against the direction of absolute plate motion. This pattern, observed in numerous other studies of teleseismic shear wave splitting, is widely attributed to plume-like upwellings of the mantle. We interpret our measurements to be the result of a shallow plume-like upwelling of the upper mantle below the northwestern North Island, complementing existing results and interpretations from earlier work.

Developing a 3D depth model and 3D rate model of Aotearoa New Zealand's upper-plate earthquakes

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Statistical spatial earthquake-rate models, such as smoothed seismicity models, are usually done in 2D (mapview). In probabilistic seismic hazard assessment (PSHA), these 2D models are often paired with a 1D depth distribution of earthquakes, or an upper and lower depth. This "2D+1D" approach is often justifiable: catalogued earthquake depths (especially of older events) are often too poorly constrained to justify further model complexity. However, there is one seismically hazardous environment where 2D and 1D models struggle: subduction zones. The 3D nature of subduction zones is actually particularly palpable in PSHA, because upper-plate, subduction-interface and intraslab earthquakes produce very different ground motions and hazards, and so have to be modelled with separate earthquake-rate and ground-motion models. Therefore, subduction zones require 3D earthquake-rate models (even though catalogued event depths are often at their lowest quality in shallow subduction zones because they are almost always offshore).

However, 2D earthquake-rate models are indispensable in their own right: among other advantages, they can represent important earthquakes that predate or lack good depth constraints (e.g., anything before the early to late 20th century, depending on location). The advantages of 2D and 3D models can both be leveraged by replacing the 2D+1D approach with a 2D+3D approach, where the 3D part is a continuously spatially varying earthquake depth-density function (a different 1D depth distribution at each point on the map). In Aotearoa New Zealand, we are working on using this method to pair longer earthquake histories (2D) with representative models of 3D seismotectonic structure, both in Aotearoa's two subduction zones (Hikurangi-Kermadec and Puysegur) and including volcanic regions and deep sedimentary basins.

The 1891 M~6.2 Port Waikato earthquake and other past seismicity in Auckland/Northland, and geodetic measurements of strain rates

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Although the Auckland/Northland region has fewer earthquakes than most of the rest of New Zealand, it has not completely avoided them historically. (https://tinyurl.com/1835-2020-earthquakes shows recorded earthquakes through 2020). The largest verified earthquake in the region struck off Port Waikato on 24 June 1891 and had an estimated magnitude of 6.2 (the same size as the 2011 Christchurch earthquake). M>=5 earthquakes also struck the Coromandel in 1937 and the Waikato in 1912, 1927 and 2023, and M~4.5 quakes struck near Peria (northern Northland) in 1963 and off Whangarei Heads in 2019.

Alongside these, there are historical Auckland-area earthquakes that crop up in catalogues but may (or may not) be red herrings. An 1891 academic letter [Vennell, 1891] reported having heard recollections of a severe earthquake sequence in Auckland in about 1835, but later archival research turned up no trace of it [Eiby, 1955]. The alleged 1835 event was included in NZ's original 1968 and 1976 earthquake catalogues with estimated magnitude 6.5 (a default value representing "strong"), and so it has come down to us as a M=6.5 event, but the uncertainty known to the original compilers is important to emphasise - the event may be erroneous or may have occurred elsewhere. Similarly, moderate earthquakes near Auckland in 1950 and 1952 crop up in catalogues, but may be mislocated events that occurred elsewhere.

Here, we will review these earthquakes and the seismicity of Auckland/Northland, along with recently acquired geodetic measurements of crustal motions and strain rates, and discuss the implications of both datasets for seismic hazard.

Tectonic and magmatic controls on multi-crater vent formation from 3D mapping of the Modgunn vent, offshore mid-Norway

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Hydrothermal vent complexes (HTVCs) form soon after magma emplacement in sedimentary basins, when rapid heating of surrounding rocks causes explosive release of fluids and sediments to the surface. Hydrothermal venting transports large volumes of thermogenic greenhouse gases from the subsurface into the ocean-atmosphere system, and has therefore been proposed as a trigger for ancient global warming events. Across the North Atlantic Ocean, hundreds of HTVCs have been documented, and their stratigraphic positions align with magma emplacement of the North Atlantic Igneous Province. However, their potential role in initiating the Paleocene-Eocene Thermal Maximum (~56 Ma) remains uncertain, in part due to limited understanding of the deeper structural controls on vent formation.

Here, we use high-resolution P-cable and lower frequency industry 3D seismic data to analyse the spatial and temporal evolution of the Modgunn vent, a HTVC on the mid-Norwegian continental margin that was dated active during the PETM. Its shallow subsurface setting allows for detailed investigation of its complex structural evolution and enigmatic multi-crater morphology. This makes it an ideal case study for studying the interplay between structural framework, magmatism, and fluidization processes. Detailed mapping of the Modgunn vent components shows that underlying sill intrusions fed individual, multiple or reused pre-existing fluid conduits, each producing a smaller depression within the vent crater (subcrater). We propose that inherited fault systems controlled the overall distribution of HTVCs in the study area, whereas the internal multi-crater morphology resulted from forced folding of deeper sills, which in turn triggered the abrupt transgression of shallower, later intruding sills. These later intrusions added adjacent conduits and subcraters. This process explains the high conduit density in the region and further suggests a potential self-accelerating mechanism, in which multiple vents erupt in rapid succession, releasing carbon over a short time span, possibly initiating global warming events.

Integrating remote sensing with iwi-guided monitoring of Mount Ruapehu

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For centuries iwi have been carefully observing the environment. These observations inform iwi on the health of the surrounding lands, water, and sky, as well as any potential current and future hazards. Mt. Ruapehu is Aotearoa New Zealand's most active onshore volcano and holds spiritual and historical significance to the local iwi Ngāti Rangi who monitor environmental changes across the Central Volcanic Plateau (CVP). This monitoring comprises regular visits to significant sites and includes direct and indirect sampling of water and land characteristics.

Here, we investigate whether this long-term in situ monitoring can be enriched with data available via remote sensing techniques. We look specifically at addressing temporal and/or spatial gaps, when and where access to a site may be limited, as well as how this project may contribute to the emerging practice of iwi-guided remote sensing use. This will serve as an example of how utilisation of remote sensing may aid iwi environmental management programmes. Through the process, we expect to illuminate both the benefits and challenges of implementing this technology within existing, and well-established Māori environmental management frameworks.

Understanding the human side of earthquake early warning: exploring key response factors

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Earthquakes pose a major risk to human life, particularly in densely populated and seismically active regions. Although current technology cannot predict earthquakes, Earthquake Early Warning (EEW) systems can provide a few seconds of advance notice before shaking begins; time that can be critical for taking protective action. However, the effectiveness of EEW systems depend not only on technical performance but also on how people interpret and respond to alerts.

This study investigates the human dimensions of EEW response, synthesising findings from New Zealand, Japan, the United States, and other contexts. We organise influencing factors into four interconnected domains: social, cognitive, demographic, and environmental. These domains include variables such as culture, education, past experience, trust, risk perception, age, gender, and caregiving responsibilities, among others, all of which shape how individuals assess risk and make decisions under pressure.

While EEW systems are typically evaluated based on speed and accuracy, our research highlights the importance of social context, cognitive processes, and demographic factors. For example, cultural norms may override official guidance; trust in the alert source influences response time; and caregiving roles or earthquake experience affect behavioural choices. Socioeconomic disparities also impact access to warnings and the ability to act safely.

Many of these human factors remain underexplored in EEW-specific research. By drawing on wider literature related to earthquakes, this study supports the development of EEW systems that are not only technically robust but also socially responsive and inclusive. Such systems have the potential to enhance protective actions, reduce injuries, and ultimately save lives.

Investigating a potential trace element biosignature of silica-microbe interactions in hot springs through synchrotron-based gallium XANES

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Discovering evidence of life beyond Earth remains a primary aim of astrobiology and is an important driver of planetary exploration. However, since organic biosignatures degrade with time, inorganic geochemical indicators of biological activity may provide important evidence of ancient microbial activity. Hot spring environments on Earth are increasingly utilised as analogue environments for potential extraterrestrial life and have similar textures to silica deposits found on Mars (Gusev crater). This study utilises both synchrotron-based X-ray fluorescence (sXRF) and X-ray Absorption Near Edge Spectroscopy (XANES) from the Australian Synchrotron to investigate the valence and coordination environment of gallium associated with microbial textures from hot springs silica (sinter), which serve as an analogue to the Martian silica deposits.

Gallium, enriched up to ~1400 ppm compared to a background of 20-30 ppm in most geologic materials, is the most widespread trace metal consistently associated with microbial material in modern sinter deposits. Gallium XANES results indicate two distinct coordination environments (tetrahedral or octahedral), based on standard comparisons. Tetrahedrally coordinated Ga appears to be associated both with silicified microbial textures in sinter as well as in higher temperature hydrothermal veining (assumed abiotic), while octahedrally coordinated Ga is observed in overprinting Fe-rich hydrothermal fluids. The lack of distinct coordination or valence change in Ga associated with microbially-induced textures in sinter may suggest that Ga is not bound to organic compounds, despite the clear chemical enrichment within the microbial structures.

Locked in stone: magma flow directions and country rock heating around the Jagged Rocks Dikes, Hopi Buttes Volcanic Field

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We studied a near-surface dike system by combining dike-fabric analysis with a paleomagnetic study of the adjacent country rock to constrain flow behaviour and heat transfer processes related to emplacement of a dike in the Hopi Buttes Volcanic Field.

The ~1500-m-long, half-meter-wide, NW-striking, segmented basanite dike is characterized by margin-parallel banding, visible mostly as changes in vesicle shape, abundance and distribution, with observable imbrication patterns, that could provide clues about magma flow directions while the dike was active. The dike intrudes clay-rich mudrock with no clear evidence in the field of contact metamorphism, except for scattered baked clasts along the dike's length. The nature of this contact raises questions about the degree of heating imposed by the (presumed) feeder dike.

For the dike-fabric analysis, we mapped ~10,000 vesicles and ~2,500 clinopyroxene phenocrysts and megacrysts in fourteen photomosaics of horizontal exposures along the length of the dike. The vesicle fabric analysis indicates sub-horizontal magma flow, consistent with another study's Anisotropy of Magnetic Susceptibility data from the dike. In several sites, however, the two indicators differ in the sense of flow: paired imbricated vesicles clearly record lateral transport in opposing directions (NW and SE), while in some sites, the AMS sense was not resolved. The shifts in flow direction occur over meter-scale distances in individual dike segments, suggesting localized changes in flow dynamics.

For the paleomagnetic study, we sampled two dike-perpendicular transects into the host mud rock. Results from thermal demagnetization reveal that the dike heated the first half-meter of intruded mudrock, resulting in its partial to complete remagnetization, and magnetic mineral analyses revealed magnetite in mudrock close to the dike which we suggest either precipitated from hematite in the host rock or was precipitated. We continue analyzing these signatures to understand heating duration and dominant heat transfer mechanisms

Thermo-rheological feedback in dikes: insights from analogue experiments and numerical modelling

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The thermal evolution of magmatic conduits plays a critical role in determining eruption dynamics. In dikes, heat conduction from the hot magma to the surrounding cold country rock leads to the formation of chilled margins, cooling fronts, and viscosity gradients within the active dike. These thermal features influence flow localization and can ultimately lead to flow arrest, directly impacting a feeder dike's ability to sustain a fissure eruption and the associated hazards.

Here we use a laboratory setup that reproduces the key processes of viscous flow and cooling in active dikes. Using PEG600, a fluid with temperature-dependent viscosity, we simulate thermo-rheological processes observed in natural magmatic systems. In an experiment we track temperature distributions and flow patterns under varying initial conditions, to qualitatively and quantitatively assess the spatio-temporal evolution of magma-like flow in a dike analogue. By varying conduit width, boundary temperatures, and injection rates, we explore how thermal exchange and flow morphology evolve in an experimental fissure eruption.

Our results provide constraints on the efficiency of conductive cooling at the walls of dikes; how long-lived conduits can remain active and how slower viscous flow domains seal and block segments of a dike. Initial conditions are enhanced by feedback processes, wherein flow is diverted away from cold, narrow zones to warmer, wider active conduits. The addition of small-scale asperities and pre-existing pathways in the dikes further enhances feedback on the viscous flow producing unstable trails of slow-flowing wax downflow (upwards in the conduit) that eventually seal off regions along the length of the dike.

After validating numerical simulations with the experimental results, we will extend our models to natural dike systems and account for the coupled effects of geometry, temperature, and phase change in the evolution of magma flow in dikes.

GeoNet earthquake monitoring evolution 2025: modernizing event detection and catalogue workflows

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The GeoNet program, launched in 2001, operates a comprehensive network of instruments enabling continuous automated and rapid multi-hazard monitoring across New Zealand's areas of interest. Over the past two decades, GeoNet has successfully developed its operational instrumental network and modernized its services. Additionally, it integrated functions with the 24/7 manned National GeoHazards Monitoring Center (NGMC) in 2019. The original objectives remain today: to facilitate observation and detection, to trigger rapid response to geohazards, and to improve and develop data gathering and services as it distributes data to the public, scientists, and emergency management bodies.

Since the implementation of "GeoNet Rapid" in 2012, which established a fast, automated, and resilient earthquake location system (ELS) workflow, changes and evolution in seismic data availability, hardware models, and data processing techniques have notably expanded operational prospects for earthquake detection and monitoring.

The GeoNet programme has committed to revisiting its ELS to improve operational requirements for maintaining and supporting a curated rapid earthquake detection system, and to enable more complete event source parameters in its catalogue. The present initiative aims to create a system architecture allowing more depth in event analysis. It also enables a framework to develop future ELS modularity with the objective of mitigating inevitable trade-offs between long-time scale data products consistency and long-term evolution of techniques and processing.

This presentation describes the early phases of planned changes to be implemented in the short term: an earthquake location system architecture workflow with an ancillary event cataloguing environment (satellite of "GeoNet Rapid") and a practical and operational deployment of the New Zealand local magnitude scale (MLnz20). These changes explore upgraded software versions, services, and features that would improve waveform and event parameter description processing and dissemination, ultimately paving the way for new operational ELS workflows.

Seismicity within the creeping and locked zones in the southern Hikurangi Margin

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Two deployments of ocean bottom seismometers offshore the southern Hikurangi Margin of New Zealand highlight penetration of seismicity across the “locked” zone determined from onshore geodetic stations.

Between October 2020 and October 2021, the “PULSE” project deployed ten ocean bottom seismometers (OBS) and 14 absolute pressure gauges straddling the southern “locking” boundary south of the Hawkes’ Bay region offshore New Zealand. With a further 48 onshore temporary stations, the combined seismic network produced a catalogue of over 34,000 earthquakes and captured a 7-day-long slow-slip event (SSE) in 2021, with slip up to 200 mm. It is part of a sequence of SSEs occurring roughly every 5 years. Earthquakes and tremors in the subducting plate occurred directly below and during the time of the SSE, with the earthquakes migrating southward into the locked zone. These earthquakes were also active 60-45 days prior to the SSE. Changes in stress ratios determined from focal mechanisms during the offshore SSE are not conclusive. But stress ratios associated with a deep, onshore SSE (Manawatu) are low (suggesting high pore pressure) when GNSS stations reverse their motion. This is consistent with the fault-valve model of SSEs.

Between December 2023 and January 2025, another set of 18 OBS recorded earthquakes in the locked zone further south (the “ELVES” deployment), re-occupying the two southern-most PULSE OBS sites and sampling the ocean floor on both sides of the trench. Preliminary relocations of 16 events located first by the permanent GeoNet network, but incorporating arrival times from the ELVES OBS stations, reveal earthquakes within the slab and on the plate boundary, somewhat shallower than those determined by the permanent network alone.

The Volcano WakaLab at Teneikoula Volcano, Solomon Islands

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The Volcano WakaLab represents an effort to merge modern technology with traditional knowledge to help fill important gaps in our understanding of active volcanism in the Pacific. The concept was to turn a traditional double-hulled sailing waka into a mobile volcano observatory to permit in-depth study of gas and aerosol emissions from all active volcanoes in Melanesia. After a series of delays and setbacks, the WakaLab finally came to fruition in May-July, 2025. We present an update on the challenges and triumphs associated with the WakaLab project, centred on the example of Teneikoula (Tinakula) volcano, Temotu Province, Solomon Islands.

Teneikoula is the 796 m subaerial summit of a stratovolcano in the Santa Cruz Islands, Eastern Solomon Islands, at the northern end of the Vanuatu Arc. Despite being frequently active, the now-uninhabited island volcano has been the subject of very few studies. The WakaLab visited Teneikoula, making the first measurements of SO_2 flux, and concentrations of H_2O, CO_2, SO_2, H_2S, HCl, HBr, and HF in an active plume. Results will be key in understanding volcanic emissions in the Solomon Islands, and along-arc variability in volcanic emissions.

Toward a New Zealand community velocity model

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The accurate description of physical rock properties from the source location of an earthquake to the surface is a foundational component of earthquake science. Here, we report on progress towards improving regional seismic velocity models that includes the characterisation of New Zealand-specific physical rock properties, estimation of site-response parameters used to model shaking intensity and the determination of subsurface velocity structure at a range of scales. These data contribute to the development of a new generation of high-resolution velocity models required for physics-based simulations of earthquakes and tsunami.

Geological and geophysical exploration data, such as lithological and wireline logs and vertical seismic profiles, constrain the velocity structure within New Zealand sedimentary strata. Relationships between compressional (Vp) and shear (Vs) seismic velocities are compared to empirical functions commonly employed for velocity model construction and ground-motion analysis. Paired Vp and Vs data from exploration wells are consistent with the current version of the New Zealand-wide velocity model (nzw3.1) indicating relationships between Vp, Vs and density can be readily improved for local application.

We extend a high-resolution velocity model into the southern Taranaki Basin using onshore-offshore active source first arrival times complemented by an existing basin model. The resulting precise travel-time interpretations provide independent constraint and validation for any regional velocity model. The methodology used in this study can be extended further to a nationwide scale using velocity and sedimentary thickness data from wells and seismic-reflection surveys offshore of western North Island and eastern South Island.

Held by the Ministry of Business, Innovation & Employment (MBIE), New Zealand has a wealth of high-quality publicly available exploration data. While acquired specifically for resource exploration, these existing data are an under-utilised resource that can be re purposed to support a range of geological, geotechnical and geophysical studies underpinning geohazard research.

How tough is pounamu? Results of fracture-toughness measurements on New Zealand’s nephrite jade

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Widely valued by Māori for both cultural and functional reasons, pounamu was traditionally crafted into tools, weapons, and adornments. Despite being recognised for its exceptional toughness and resistance to fracture, quantitative data on pounamu’s fracture toughness and flexural strength are notably absent from the literature. The present study addresses this gap by measuring these properties on nine nephrite jade (pounamu) samples from New Zealand and comparing results with values reported for overseas jade (from Australia, Canada, Russia, Switzerland and USA).
Flexural strength and fracture toughness (K1c) were measured using a universal testing machine in a four-point bending configuration, following ISO 6872. For testing, each of the nine samples was cut into 7-15 separate elongated cuboid subsamples (3×4×25 mm).

Mean fracture toughness values for pounamu samples ranged from 6.79±1.4 to 15.01±5.63 MPa·$m^{0.5}$, which exceed previously reported measurements from overseas nephrite jade of 1.9–7.7 MPa·$m^{0.5}$. Flexural strength measured on the same pounamu samples returned a broad range of values, from 42.48±12 to 128.99±16 MPa, similar to the wide ranges found elsewhere (22 to 295 MPa).

In conclusion, pounamu exhibits exceptionally high fracture-toughness, with the highest values recorded to date for nephrite, indicating strong resistance to crack propagation. An interesting feature of all jade results measured so far is comparatively moderate flexural strength, suggesting a limited capacity to withstand bending stresses. This may result from microcracks, pores, or weak grain boundaries within the material. Further research is being conducted to clarify the factors that contribute to the toughness and other material properties of pounamu.

Does pre-ascent magma storage influence eruption style?

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Understanding the subterranean conditions that are optimum for initiating distinct styles of volcanic activity are important in assessing hazards. The eruption style is strongly influenced by magma ascent rate and efficiency of volatile outgassing. These relate to conduit permeability and occur in the upper ~0-3 km of the system. However, from a hazard perspective, magma storage days to years prior to final ascent may provide a timeframe for mitigation strategies. This time window is recorded by phenocryst growth.

To explore the influence of pre-ascent conditions on eruption style, we examined plagioclase and amphiboles phenocrysts in andesitic-dacitic magmas erupted explosively and effusively at Taranaki volcano. Regardless of their eruption style, the assembly of each eruptible magma batch was broadly similar. Specifically, the co-eruption of isotopically and texturally discordant phenocrysts is best explained by the periodic intrusive disruption of a redeveloping crystal mush that lacked a unidirectional assimilation-fractional-crystallisation path over a centennial timescale, the time between eruptions.

Amphiboles from most effusive eruptions are distinguished from their explosive counterparts by recording late-stage halogen (and other volatile?) accumulation and subsequent decomposition during slow magma ascent. In addition, plagioclase textures recording late-stage mingling with a mafic melt are more prevalent in effusive eruptions. Thus, it is possible that the pre-eruption magma conditions of heating, viscosity reduction and enhanced outgassing promoted effusive events such as dome building. Independent estimates of magmatic volatile contents and temperature are needed to verify this hypothesis. Future conceptual models could test whether such thermal and volatile properties of pre-eruption magmas would be identified via geophysical monitoring. The extent of inter-crystal textural, chemical and isotopic discordance in Taranaki magmas shows that experimental and thermodynamic thermobarometers can be erroneous. Chemical equilibrium does not demonstrate isotopic equilibrium, and thus, phase occurrence is not a universal indicator of an equilibrium assemblage.

Local earthquake tomography of the Wairakei-Tauhara region

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Geothermal energy, especially supercritical geothermal resources, is a sustainable energy source that is a key to reducing New Zealand's carbon emissions. Supercritical geothermal fluids are considered a significantly efficient energy resource and are expected to be located within a depth of 5km of the geothermal fields. To have sustainable geothermal energy and continue our development, we need to expand our understanding of the subsurface structure and characteristics of geothermal fields. The Wairakei-Tauhara region in the central Taupō Volcanic Zone (TVZ) hosts multiple geothermal fields such as Wairakei-Tauhara, Rotokawa, and Ngatamariki. Multiple geological, geochemical, and geophysical research have been conducted in these geothermal fields to image their subsurface structures, characteristics, and heat flows. However, current understanding of the detailed velocity structures of these geothermal fields is limited. We focus on expanding our knowledge of the 3D velocity structure by applying local earthquake tomography to P- and S-wave arrivals of local earthquakes recorded by the permanent GeoNet network and the temporary Wairakei Earthquake and Tomography Array deployed from 5 September 2023 to 24 November 2023. Of the 881 earthquakes that occurred during this period, 320 events with at least 6 P and S wave phase arrivals with azimuthal gap smaller than or equal to 160◦ were used to construct 1D VP, VS, and VP/VS models and 3D VP and VP/VS models. These 1D velocity models are more detailed, with a depth of 4km, as a significant proportion of earthquakes are located within this depth. The station corrections illustrate the lateral variation of the 1D velocity model. Based on these 1D velocity models, 3D velocity models of the region will be constructed. The resolution will be assessed by using multiple tests, such as the spread function. Our 3D velocity models will be developed and tested to assess geothermal fluid pathways and fault structure.

Reconstructing Holocene environmental change and geological development at Sandy Point, Avon-Heathcote Estuary, Christchurch, New Zealand

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The Canterbury region has a known history of tectonic activity. This includes land subsidence that may have affected coastal environments. To better understand how this has influenced the Avon-Heathcote Estuary, late Holocene environmental change at Sandy Point, on the estuary's western edge, can be reconstructed through sedimentological and paleoenvironmental analyses of new and existing sediment cores. Two sediment cores and seven gouge augers were collected and analysed for benthic foraminifera and seed preservation, with the aim of understanding estuarine evolution and the role of tectonic subsidence. No foraminifera were recovered from any samples, prompting a shift in focus to seed analysis as the primary biological proxy. Preliminary results show preserved seeds from native species in deeper layers, with exotic species in the upper stratigraphy within one of the sediment cores offering insight into past vegetation communities, environmental conditions and European arrival. This data is complemented by unpublished student findings, and regional context including radiocarbon-dated wood from an in-situ fossil forest, with ages of ~2000 years BP. The presence of kanuka, matai and other forest trees within intertidal mudflats indicates relative sea-level rise interpreted to be due to tectonic subsidence. Stratigraphic and lithological observations across our cores support a history of estuarine infilling, shoreline migration, and episodic environmental change. Sandy Point, now enclosed within the estuary, is interpreted as a relict spit reflecting an older coastal margin. The combination of subsurface data, seed distributions, and historical shoreline positions builds a picture of dynamic landscape change through the late Holocene. While foraminifera absence limited direct sea-level reconstruction, seed data offer a valuable alternative for interpreting vegetation shifts and relative environmental conditions and offer age control for younger sediments. This study highlights the effectiveness of a multi-proxy approach in coastal paleoenvironmental reconstruction and underscores the importance of considering tectonic processes in estuarine evolution.

It’s a gas!: volcanic emissions and fluxes in the Auckland Volcanic Field, Aotearoa New Zealand

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Volcanic gas data are critical for hazard assessments for volcanic regions near populations and infrastructure, such as the distributed, basaltic Auckland Volcanic Field (AVF; last eruption ~1446 CE). However, directly measured and analogue emissions and flux data are scarce for long-dormant and/or unmonitored volcanic systems. We first address this gap by estimating volatile emissions from a compositionally representative set of five AVF eruptions with the petrologic method using new crystal-hosted melt inclusions and groundmass glass volatile concentrations. Using these new emissions estimates, a novel approach to estimate daily volatile fluxes for eight DEVORA AVF eruption scenarios was developed. Due to uncertainties in AVF magma ascent behaviour, both open- and closed-system fluxes were modelled. Open-system fluxes were derived by coupling unrest timelines with a thermodynamic magma degassing model, EVo, while closed-system fluxes were estimated by distributing emissions for each scenario over a simple log-normal magma discharge curve, defined by the scenario eruption durations. Maximum time-averaged fluxes for eruption scenarios are >80,000 tonnes/day CO_2, >63,000 t/d SO_2, >3,000 t/d HCl, and >5,400 t/d HF, far exceeding emissions from man-made point sources. Model outputs also show that maximum daily SO_2 fluxes from AVF eruptions may rival those observed in recent high-impact eruptions, such as at Miyakejima 2000 and La Palma 2021, though results are heavily dependent on scenario parameters. Findings indicate that eruptions in small-volume distributed volcanic fields are capable of producing emissions and fluxes comparable to polygenetic eruptions, though overall contribute a negligible proportion to the total annual global volcanic gas budget.

Our study presents the first volatile emissions and flux estimates for the AVF and describes a novel, transferable approach. The results support realistic eruption scenario development, may be fed into gas dispersion models, and can ultimately be used to improve emergency preparedness for volcanic gas hazards in long-dormant or unmonitored volcanic regions.

Synchronous and asynchronous ambient seismic noise tomography of the South Island, New Zealand, using a novel broadband array along the Alpine Fault

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The Alpine Fault, New Zealand, is likely to produce a great earthquake in the next 50 years, yet its subsurface structure is poorly constrained due to a lack of data coverage. We develop a shear wave velocity model of the South Island using recordings of ambient seismic noise over the last 25 years by the national seismic network, several temporary networks, and the novel quasilinear SALSA array of broadband seismometers installed along approximately 400 km of the fault length. We cross-correlate contemporaneous recordings of ambient seismic noise to obtain synchronous empirical Green's functions (EGFs) between receiver pairs. We also obtain asynchronous EGFs between receiver pairs active during different time periods, by cross-correlating synchronous EGFs between each receiver in the pair and a common colinear contemporaneous receiver. Surface wave dispersion measurements of the phase and group travel times of fundamental mode Rayleigh waves from the EGFs are used to compute the posterior probability distribution of the 3D shear wave velocity model by Bayesian one-step surface wave inversion. Instead of using computationally expensive Monte Carlo based approaches, we solve this problem with variational inference using normalising flows. Our model increases the resolution of crustal structure around the Alpine Fault, showing clear changes in crustal structure of the Southern Alps along the strike of the island, with a full description of model uncertainty, improving on the current shear wave velocity models of the South Island.

Exceptional normal fault offsets in the aftermath of the 232 CE Taupō eruption

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Phases of accelerated normal faulting in the Taupō Volcanic Zone have been demonstrated to be triggered by rhyolite eruptions, yet little is known about how the Taupō Fault Belt responds in the aftermath of caldera-forming events, particularly the 232 CE Taupō eruption. To address this issue, we conducted paleoseismic trenching coupled with remote and field analyses of the Whakaipō Fault (north Taupō) and the displaced post-232 CE paleoshorelines intersected by this structure. The throw profiles along the Whakaipō Fault reveal increasing throw in proximity to Lake Taupō, highlighting the importance of Taupō volcano (in particular the 232 CE caldera margin) for localising fault strain. Paleoseismic trenching exposed a ~50° dipping un-degraded paleoscarp draped by fall deposits of the 232 CE eruption, implying that fault slip occurred in the days to months preceding the eruption. Analysis of fault and paleoshoreline displacements at Whakaipō Bay on the northern shoreline of Lake Taupō suggest that two main phases of slip on the Whakaipō Fault occurred: (1) an "aftermath" phase, occurring over a ~10-20-year period after the 232 CE eruption, during which 5-10 m of throw was accrued locally on the fault; and (2) a subsequent "longer-term" phase through to the present day, during which 2.8 ± 0.3 m of fault throw has accrued. Faulting during the aftermath phase is estimated to account for ~75% of the total extension accommodated locally on the Whakaipō Fault since 232 CE, and demonstrates that exceptionally large (>10 m) normal fault displacements may accrue along the Taupō Fault Belt in association with caldera-forming eruptions.

Strengthening science identity and interdisciplinary STEM engagement: he Scientists in Schools initiative at the University of Canterbury

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In Aotearoa, the erosion of science engagement as students move from intermediate (for students aged 11-13 years) into the secondary schooling system (for students aged 13-18 years) is well-recognized. Engagement is variable in primary years, by age 15, only around two-thirds of New Zealand students report an interest in science (PISA, 2006). One way to counteract this challenge is through targeted educational programs that engage students in interdisciplinary STEM experiences.

The Scientists in Schools (SIS) program, developed by University of Canterbury (UC) scientists and educators, is a collaborative initiative with UC science students and local schoolteachers that aims to address the challenge of declining science engagement at the secondary school level. This collaborative approach ensures that the program is tailored to the unique context of each school, to help deliver lasting interdisciplinary STEM experiences.

SIS provides a science communication internship for science undergraduates to translate authentic science experiences into the classroom and become relatable STEM role models. The program also fosters a potential science-communication pathway within their undergraduate degree. Through curriculum-aligned co-design, teachers and researchers collaboratively develop hands-on learning modules tailored to Year 9-10 classrooms. During the co-delivery of authentic STEM activities, students, teachers, researchers, and mentors jointly engage in real-world experiences—experiments, fieldwork, games—linking university research with school curriculum and embedding longer-term projects.

Finally, to evaluate the SIS program, reflective interviews with teachers and UC science participants will be used as evidence of the program's impact and explore its role in developing STEM pathways and STEM literate citizens.

Imaging the Auckland Volcanic Field upper lithosphere with local body-wave tomography

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We present high-resolution 3D Vp and Vs models of the uppermost ~10 km beneath Tāmaki Makaurau Auckland, providing new insights into lithospheric structures and processes beneath the Auckland Volcanic Field (AVF).

The AVF is one of many monogenetic volcanic fields worldwide whose origin—from source to surface—remains poorly constrained. Its urban and intraplate setting means that local earthquakes are sparse, and their recording noisy. This has long discouraged using body-wave travel times from local earthquakes for imaging the upper lithosphere with seismic tomography. We overcome this challenge by applying the FMTOMO inversion software to a critically reviewed dataset of 580 P-wave and 437 S-wave travel times from 71 local earthquakes in GeoNet's catalogue, recorded at 12 stations in the Auckland Volcanic-Seismic Network.

Our final Vp and Vs models reveal anomalously slow velocities beneath the AVF, interpreted as a potential superposition of thermal weakening from residual stalled magma, serpentinisation of the Dun Mountain Ophiolite Belt (DMOB), or the incorporation of adjacent metasedimentary material into the ultramafic basement. To the east, anomalously high velocities align with exhumed Waipapa Terrane blocks, consistent with the uplift of higher-grade metamorphic material along major basement faults. We identify two previously unmapped, seemingly active faults striking NNE–SSW: one extending from Rangitoto volcano into the Hauraki Gulf, and the other bisecting western Waiheke Island. Onshore extensions of these lineaments challenge existing fault maps. A low-velocity zone beneath northern Waiheke Island may be linked to fluid migration and tectonic processes of the Hauraki Rift. More broadly, subsurface fluids appear to influence at least a subset of the seismic events in Auckland—evidenced by the presence of swarms, and earthquakes typically occurring in fast Waipapa Terrane rocks, when anomalously slow material is nearby.

Facies control on the distribution of organics and reactive minerals in potential hydrogen geostorage sedimentary reservoirs

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The use of sedimentary reservoirs for underground storage of green hydrogen has been the interest of recent studies, with the aim of reducing dependence on fossil fuels globally. Within New Zealand, the Taranaki Basin is the only location with producing oil and gas reservoirs, many of which will be depleted in the coming decades. These sites provide an opportunity for the region to transition to the storage of green hydrogen. However, as hydrogen gas is potentially reactive with components such as organic material, pyrite and carbonates, it is important to examine the composition of potential storage reservoirs as part of site evaluation.

Organics within sedimentary facies can be found in coal seams, but can also be disseminated throughout sandstone and mudstone facies. The surface area to volume ratio of organic matter in sedimentary facies is likely to affect the ability for stored hydrogen to adsorb and be lost. Pyrite is often associated with organic matter and even small amounts may react with stored hydrogen to form the toxic H2S gas. Therefore, characterising the quantity and distribution (e.g., size/shape) of organics, pyrite, and other potentially reactive material within sedimentary facies is important to help assess the suitability of depleted petroleum reservoirs for hydrogen geostorage.

Our project investigates the distribution of organic matter and authigenic minerals within three high-ranking oil and gas sites for hydrogen geostorage from the Kapuni Group in Taranaki Basin. Using both core and field analogues from fluvial, marginal marine and shallow marine facies, we aim to evaluate the lateral and vertical distribution of potentially reactive material in the relevant microfacies (i.e. channel, point bar, swamp etc.) to estimate the overall risk of hydrogen reactivity for the chosen geostorage sites.

Post-eruptive ocean response at Hunga Volcano, Tonga

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The Tonga-Kermadec Arc hosts ~80 submarine volcanoes, being one of the most active volcanic regions on Earth. The explosive eruptions of these submarine volcanoes can strongly influence ocean chemistry and nutrient availability, shaping post-eruptive biological productivity and ecosystem recovery. Despite this, submarine eruptions remain vastly understudied, and the environmental consequences poorly constrained.

The 2022 eruption of Hunga Volcano caused mass-mortality of seafloor life and revealed critical uncertainty of long-term effects on the ocean system. This project takes advantage of the rare opportunity to utilize post-eruptive oceanographic data to analyse how the ocean changes following a shallow submarine volcanic eruption.

Here we present preliminary results of conductivity-temperature-depth (CTD) vertical profiles and water samples taken at targeted depths, collected during the August-September 2025 VEERI-HOT voyage to Hunga Volcano onboard the RV Investigator. These datasets are used to analyse the water column structure and determine the compositions of the particles in the water column. This data will help determine how concentrations change with distance outside of the volcano, as well as vertically within the highly stratified caldera compared to the well-mixed ambient ocean. This research will provide new insights on how submarine volcanism drives geochemical cycling and ecosystem recovery in a shallow submarine volcanic environment.

EarthFest – Festival of Earth Science – What is it? What's the goal? What's next?

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EarthFest - Festival of Earth Science is a public open day that has been held annually in association with the Geoscience Society of New Zealand conference since 2023. Now in its third year, EarthFest has gained a reputation as a worthy enterprise and is beginning to establish itself as an expected part of the conference programme.

EarthFest was inspired by VolcanoFest – a public outreach event that celebrated volcanoes through art, science, and hands-on activities, held in association with the International Association of Volcanology and Chemistry of the Earth's Interior (IAVCEI) Scientific Assembly hosted in Rotorua in 2023. VolcanoFest was a great way to reach and engage teachers, students and the general public with volcano science. So, why not host a similar event in association with the GSNZ conference celebrating all the geosciences? Very much in the spirit of "let's try it and see" EarthFest was born…and has continued!

Over its past 3+ events, EarthFest has adapted depending on the location of the GSNZ conference and levels of sponsorship and other support it has received. It has even begun branching out into independent regional events, which is hopefully a sign of things to come.

For those involved behind the scenes, organising EarthFest has been a crash course in event management that has paid dividends in terms of networking and diverse skills development. But most important of all, over the past three years EarthFest has been able to reach thousands of people, including hundreds of children and their families, many of whom did not want to leave. We hope some of them will become future geoscientists!

This presentation is a thank you to all those who have been involved and will provide an overview of EarthFest activities to date, and what our next steps might be.

Fifty years of shore platform erosion monitoring at Kaikōura Peninsula, South Island, Aotearoa-New Zealand

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The Kaikōura Peninsula, located on the tectonically active east coast of South Island, New Zealand, hosts the world's longest-running records of shore platform erosion. Since 1974, a network of Micro-Erosion Meter (MEM) stations has been used to measure vertical surface downwearing across mudstone and limestone platforms. Here, we synthesise five decades of observations to assess spatial and temporal patterns of erosion, evaluate the consistency of downwearing rates, and quantify the geomorphic response to one metre of coseismic uplift associated with the 2016 Mw 7.8 Kaikōura earthquake. Pre-earthquake erosion rates averaged 1.1 mm yr^{-1} and showed little change over decadal intervals. Post-earthquake rates more than doubled on uplifted mudstone platforms, reflecting enhanced subaerial weathering due to increased subaerial exposure and desiccation. Limestone platforms tended to erode more slowly, and statistical testing revealed a significant difference in mean erosion rates between the two rock types that had not been evident before the November 2016 uplift. Seasonal differences in erosion with higher rates in summer than winter, well documented prior to the earthquake, disappeared after 2016. These findings highlight the critical role of changing subaerial processes, the geomorphic significance of tectonic events on rock coasts, and the pathway from shore platform to marine terrace generation. The Kaikōura dataset provides a globally significant reference for interpreting short- and long-term erosion dynamics and highlights the scientific legacy of the late Emeritus Professor R.M. (Bob) Kirk.

Evaluating the New Zealand National Seismic Hazard Model 2022 with fragile geologic features

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In the past two years effort has gone into understanding and evaluating the biggest increases in estimated hazard in the New Zealand National Seismic Hazard Model 2022 (NZ NSHM 2022) relative to NZ NSHM 2010. The southeastern North Island shows a greater-than-factor-of-two increase in peak ground acceleration for the 500-year return period. In this area, the new Hikurangi subduction zone ground motion modeling has driven this increase, along with an additional increase attributed to crustal sources. Our work has involved reconnaissance of the coastal eastern North Island (above the Hikurangi subduction interface) for fragile geologic features (FGFs) such as sea stacks, balanced rocks, and unstable delaminated rock slabs. FGFs at two sites, White Rock and Cape Palliser, were subsequently studied. A greywacke FGF at Palliser is balanced on a sloping pedestal, and its fragility has been quantified according to assumptions of toppling and sliding. Fragilities of delaminated carbonate rock slabs on a large sea stack at White Rock have been quantified according to assumptions of rocking. 10Be and 36Cl cosmogenic exposure dating has shown the fragility ages of the carbonate FGFs to be about 0.9–2.2 kyr BP, and the greywacke FGF to be 1.8-2.9 kyr BP. The FGFs are older than the last Hikurangi subduction interface megaquake that occurred less than 1 kyr ago, and will therefore provide useful constraints on the associated ground motions.

Evaluating the reliability of post-volcanic eruption building damage data collection methods

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Post-event impact assessments are used to inform emergency response and recovery by characterizing and quantifying the consequences and damage sustained by communities after volcanic eruptions.

Timely data to inform such assessments can be difficult to obtain due to the widespread and heterogeneous nature of volcanic impacts. This has necessitated the use of various data collection methods including field surveys, crowd-sourced information, and satellite and aerial imagery capture. However, data typologies and reliability between and within these methods can vary substantially. Data reliability can be related to data attributes, including the collection method along with the data consistency, the level of detail, data age, variation in terminology, and the completeness of the data set. Therefore, the development of a standardized framework to evaluate the reliability of post-event impact data is critical to conceptualize and understand post-event impact assessments.

Here, we will develop a framework for assessing post-event impact data reliability for use with dynamic and rapid volcanic ash impact assessments for timber-framed buildings. The reliability framework will provide key criteria for evaluating and weighting disparate data sources following an eruption. Specifically, the reliability grade will be applied to define the degree different impact data will influence rapid impact assessments that combine modelled and observed impacts following an ashfall event. This will allow for the full and appropriate utilization of observed data to be used to inform post-event impact assessments, whilst ensuring data quality is not undermined by inaccurate or poorly constrained information. The reliability framework will be trialled using a case study to investigate its application within an emergency response context.

Miocene to Holocene paleogeography of the Auckland–Northland region

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The distribution of facies with widely differing engineering properties, both in older Miocene–Pliocene and younger Quaternary deposits, has important implications for development of infrastructure across this urban or soon to be urban region. Paleogeographic maps allow the distribution of facies to be better understood and provide context for other geological studies. We present draft updated paleogeographic maps covering the wider Auckland-Northland region, from the Early Miocene through to Holocene. These maps have been informed by ongoing detailed urban geological mapping in the Auckland region (Pukekohe, Auckland volcanics and Silverdale map sheets). These new and updated maps were constructed using the widespread compilation of data from detailed surface geological mapping, subsurface boreholes, measured section and paleontological databases, and numerous previous published studies and theses.

These paleogeographic maps were chosen to capture important times in the geological evolution of northern North Island, encompassing the Auckland and Northland regions, and much of northern Waikato and the Coromandel Peninsula. Time periods covered include: the Early Miocene, to capture the evolution of the Waitematā Basin, focusing on evolving sediment transport patterns through time, and its interaction with both volcanic centres and the Northland Allochthon. Early and Late Pliocene, to capture the return and evolution of widespread sedimentation across much of the onshore region, and investigate linkages between basins in Auckland and Waikato, active faulting, and the formation of major barrier and tombolo systems. A series of Quaternary maps aim to show the evolution of the various volcanic fields through time, as well as the interaction of sedimentary systems with changes in sea-level through times of glacial lowstand and inter-glacial highstand.

Revisiting the tectono-sedimentary evolution of the Tarata Thrust Zone (Taranaki Basin, Aotearoa New Zealand): implications for future H_2 and CO_2 geostorage

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The Tarata Thrust Zone forms part of the onshore eastern border of the Taranaki Basin and is structurally linked to the Taranaki Fault. It represents a fold-and-thrust belt that has been extensively investigated for oil and gas exploration. However, published reports remain contradictory regarding, for example, structures affecting seal units as well as the orientation and kinematics of the fault zone. These uncertainties limit the overall understanding of the tectono-sedimentary evolution of this thrust zone.

In this study, we integrate multiple datasets to provide a comprehensive reassessment of the Tarata Thrust Zone. We combine openfile reprocessed and recent 2D/3D seismic reflection data with well data across the whole fault zone. This multi-scale approach allows us to place the Tarata Thrust Zone in the context of basin-wide tectonic evolution rather than focusing solely on individual petroleum plays.

Our preliminary results provide a more detailed view of the structural complexity of the Tarata Thrust Zone. Fault analyses highlight different faulting patterns including reverse and strike-slip faulting parallel to the main thrust that affect seal units. Syn-tectonic sedimentary deposits show clear unconformities and thickness variations characteristic of thrust growth. The geometry of the main thrust varies along strike, with areas of segmentation, and back-thrusting. These observations will allow us to refine the structural framework and to better constrain the relationship between thrust evolution, sedimentation patterns, and basin-scale tectonics.

Ultimately, this study will allow us to reassess existing models and evaluate the potential of the Tarata Thrust Zone for H_2 and CO_2 geostorage, expanding its relevance from traditional hydrocarbon systems to future renewable energy storage solutions.

Working with mana whenua: field protocols for research in the Auckland Volcanic Field

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Research in the Auckland Volcanic Field (AVF) occurs within a tightly interwoven framework of geology, law, and tribal governance. Many volcanic features are under co-governance between mana whenua iwi/hapū and local or national agencies, with responsibilities defined through Treaty of Waitangi settlement legislation. Scientists must recognise and respect these arrangements as legal as well as cultural obligations. This presentation distils key "field rules" for geoscientists working in the AVF.

From seismic signal to coastal impact: ESNZ's tsunami science response in action

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Since the 2016 Kaikōura earthquake, Earth Sciences New Zealand’s (ESNZ; formerly GNS) response system has evolved into a tiered, scalable Incident Management System (IMS). This scientific response function includes the National Geohazards Monitoring Centre (NGMC), 24/7 peril Duty Officers, Scientist-in-Charge (SiC), and expert panels. For the recent Kamchatka earthquake and Pacific-wide tsunami threat, ESNZ activated a Level 2 IMS response to coordinate and provide science advice to the National Emergency Management Agency (NEMA).

On Wednesday 30 July at 11:25am NZT, a magnitude 8.8 earthquake struck off Russia’s Kamchatka Peninsula. Initial magnitude estimates were lower (M8.0), which is common for large events due to limitations of early data acquisition and processing; however, they were resolved to higher magnitudes, ranging from 8.7-8.9. This earthquake generated a significant tsunami which impacted the entire Pacific Ocean (with waves up to 5m recorded).

The tsunami travelled over 10,000 km and the first recorded arrival in New Zealand was around 1am at the North Cape tsunami gauge. Significant tsunami amplitudes were recorded across the motu, with possible higher arrivals occurring along coastlines not captured by gauges. The largest recorded initial arrival phase on the mainland was 31cm but peaked at the Chatham Islands with a maximum recorded amplitude of 55cm at 06:17 on 31 July. Reflected waves from South America arrived around 00:00 Aug 1, with instrumental amplitude observations peaking at 70cm, exceeding initial wave heights. Coastal activity across Aotearoa remained elevated for several days post-quake.

ESNZ uses a wide range of tools and datasets in a tsunami response, supported by research and operational programmes like GeoNet, the RCET Endeavour and MBIE-funded Strategic Science Investment Fund. This presentation will provide an overview of the science response, tools and data used, and key observations from this event to strengthen future hazard readiness.

Modeling seismic sensor network capability with the minimum detectable earthquake magnitude

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Sensor network capability is the measure of how well a network's data serves a purpose.

There are three ways to estimate sensor network capability. The most indirect are when data are used to model a phenomenon and the quality of that model is used to infer some aspect of network capability, e.g., monitoring an earthquake sequence. More direct are approaches which use statistical analysis on network data derivatives to gain insights about the network capability, e.g., magnitude of completeness estimation. The most direct is to model the network capability using the network's raw data, e.g., minimum detectable earthquake magnitude models – this work.

Direct modeling approaches allow the network capability to be estimated at any point in time independently of event occurrence based purely on the network state, site data quality, and models that reproduce the capability measure being studied, i.e., earthquake detection. When paired with representative sampling of data variance, these approaches can approximate the outputs of statistical analysis techniques within the limitations of their underpinning models.
In this talk I present such a method for estimating the minimum detectable earthquake magnitude using an adaptation of the SN-CAST method for the GeoNet seismic sensor network and earthquake detection system.

To illustrate the method's fidelity, I compare its outputs to magnitude of completeness estimates made using GeoNet's earthquake catalogue and show their broad agreement.

To illustrate the method's utility, I present examples of network capability change due to site gains and losses, weather and earthquake-induced environmental noise variations, and network enhancements that decrease station exposure to noise. Each example could or has been used to inform GeoNet operations and taken together they showcase the value of SN-CAST for understanding sensor network capability generally and specifically regarding the real needs and interests of an operational science programme.

How benthic foraminifera relate to tidal elevation changes in Whakaraupō (Lyttelton Harbour)

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Lyttelton Harbour (Whakaraupō) is a drowned valley that has progressively filled with sediment through the late Holocene. Since European arrival, there has been significant environmental change associated with deforestation and increased sedimentation. Foraminifera can be used to estimate how much change, both natural and anthropogenic, has occurred with the harbour. Foraminifera can be used to estimate tidal elevations, as they are sensitive to sedimentation, salinity, temperature and more. Foraminifera have been sampled and identified from two cores taken within the harbour in Charteris Bay and Allandale Bay. The Charteris Bay core (JH02) had ten samples taken every 30cm, and the Allandale Bay core (JH03) has had eleven samples taken every 40cm. Ammonia aoteana dominate within every sample in both cores, Haynesina depresula is observed to increase in abundance as depth decreases in the cores, while Elphidium advenum is more abundant towards the bottom of the cores. Elphidium vellai, an invasive species, is only present in the top two samples of both cores. Other foraminifera species, such as Bolivina excavata and Bolivina neocompacta, were also seen in small amounts throughout the core. Detailed interpretation of the core is ongoing, however in summary foraminifera indicate a stable shallow subtidal to intertidal near marine salinity setting over the last several thousand years, with reduced numbers of foraminifera in upper samples of both cores. This is possibly linked to deforestation and increased sedimentation into the harbour, diluting foraminifera records. Palaeogeographic maps of the inner harbour will be created using these results, and that of others, to graphically show environmental changes in the harbour through time.

Application of Anisotropy Magnetic Susceptibility (AMS) to base surge deposits of the Auckland Volcanic Field: implications for depositional processes and runout distance

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Information about depositional processes and runout distances of base surges is essential for studying the potential hazards of future eruptions in the Auckland Volcanic Field (AVF). In this study we apply Anisotropy of Magnetic Susceptibility (AMS) to characterize flow behavior and depositional processes of past AVF base surge eruptions. Furthermore, AMS facies in pyroclastic flow and surge deposits are shown to vary with distance from the eruption source, potentially informing run-out distances. As this represents the first application of the AMS technique in the AVF, we conducted a pilot study of 144 cube samples from two proximal outcrops exposing layered succession of base surge deposits at Wiri volcano. The AMS measurements from both outcrops reveal variations in the magnetic foliation, lineation and the degree of anisotropy up-section, showing different characteristics between the earlier and later emplaced flow deposits. This variation through layers of one surge-emplaced bed suggest turbulence in initial dilute flow was subsequently suppressed as depositional rates increased, changes that may be explained by variations in flow energy, topographic interactions, and proximity to the vent. From these initial results, a sampling strategy has been developed for other key base surge outcrops in the AVF. The base surge characteristics derived from the AMS results and associated fieldwork will be combined with a thorough knowledge review of phreatomagmatism in the AVF to inform a revised conceptual model of the base surge hazard in the AVF.

Aotearoa New Zealand earthquake rupture models database

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Earthquake rupture models are developed by imaging spatiotemporal evolution of slip on faults through source inversions using seismic recordings and geodetic measurements. They constitute an important dataset to investigate rupture dynamics such as source scaling relations and slip characteristics. We further our efforts to compile a database of the rupture models for significant earthquakes in and around New Zealand. These include development of consistent file-format/s for the models, a workflow including documentation for compiling the models, and assessment using FAIR - Findability, Accessibility, Interoperability, and Reusability Score.

Insights on the kinematic rupture properties of the 2016 Mw 7.9 Kaikōura earthquake

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We analyze a dynamic rupture model of the 2016 Mw 7.9 Kaikōura earthquake to understand the properties of kinematic parameters in multi-fault ruptures. Key findings are: (1) Along-strike slip profiles taper at rupture terminations but not at fault intersections, unlike rupture velocity profiles, which show no tapering. However, average rupture velocity decreases when rupture propagated across fault bends. (2) Segment-averaged slip exceeds regional source-scaling estimations, while average rise time for the average slip is shorter than that given by a global scaling relation. At the same time, there are fault segments associated with low rupture velocities (~0.5–0.9 km/s) that exhibit low slip (<0.1 m) and long average rise time. (3) Most kinematic parameters are weakly correlated, except for a positive slip–peak slip rate correlation and a negative rise time–onset time correlation. These results characterize the rupture complexity of the multi-fault earthquake.

Seismological analysis of contemporary and future Alpine Fault seismicity using the Southern Alps Long Skinny Array (SALSA)

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The Alpine Fault is a major transpressive plate boundary known to generate great earthquakes (Mw~8) at intervals of less than 300 years, based on paleoseismological evidence. The last major rupture occurred in 1717 CE, meaning that the fault is late in its well-characterized interseismic cycle. The Southern Alps Long Skinny Array (SALSA), a ~450 km-long network of 43 broadband and four short-period seismometers spaced approximately 10 km apart, was deployed between October 2021 and November 2023 between Maruia and Piopiotahi/Milford Sound. SALSA's linear geometry was designed for virtual earthquake analysis, enabling efficient evaluation of far-field ground motions for a wide range of geologically plausible rupture scenarios. This approach allows exploration of kinematic models beyond the computational limits of full-waveform simulations. In addition to providing high-resolution ambient noise data, SALSA recorded microearthquake and tremor activity along most of the fault's onshore extent. These observations offer new insights into the fault's current state based on much more consistent detection thresholds than previously attainable using smaller-aperture networks, and inform models of future rupture behaviour. In this presentation, we describe the scientific rationale behind SALSA's deployment, highlight initial findings, and outline future research directions enabled by this unique dataset.

Full waveform inversion reveals high-resolution crustal structure within the Southern Hikurangi Margin frontal wedge: implications for physical conditions along the shallow megathrust

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In the frontal wedge of subduction zones, a range of deformational, hydrogeological, and diagenetic processes initiate and interact, creating a complex tectonic environment. Here we apply acoustic FWI on five seismic reflection profiles acquired during the 2010 PEGASUS/SAHKE seismic survey to investigate the physical state of the frontal wedge along the Southern Hikurangi Margin. Using a hybrid optimisation approach, model parameter space is explored with a high degree of freedom, greatly alleviating inversion starting-model sensitivity and susceptibility to local-minima convergence. This bypasses arduous starting-model construction and facilitates recovery of P-wave velocity (Vp) structure to depths of up to 10 km.

We find that, seaward of the deformation front, the incoming Mesozoic sequence (MES) manifests as a distinct ~2 km-thick, low-Vp (2.8–3.4 km s^{-1}) unit capped by a thin, high-Vp (5.5 to >6 km s^{-1}) unit (Sequence-Y). This corroborates inferences from previous studies, which have suggested that Sequence-Y may act as a regional seal, maintaining high fluid pressures within the underlying MES unit [e.g., Palza-Faverola et al., 2012; Crutchley et al., 2020]. Landward, Vp within the incoming sediments begins to increase ~15–25 km from the frontal thrust. This defines the bleeding edge of tectonic compression, similar to the fault-defined proto-thrust zone. Across the frontal thrust, Sequence-Y is fractured, facilitating rapid dewatering and compaction of MES as it begins to subduct. A distinct low- Vp zone at the base of the frontal thrust is likely caused by increased fluid pressure, driven by dewatering of the underlying MES unit. Further landward, a similar but spatially larger low-Vp zone exists. We suggest that this represents a zone of preserved high fluid pressure formed within preceding frontal-thrust configurations and discuss the implications for megathrust slip behaviour and tsunami hazard.

Spatial–temporal rupture patterns of reverse faults: a case study of the Dunstan Fault, Otago, New Zealand

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Tectonic geomorphology resulting from active reverse faulting is highly variable and often complex (E.g. 1988 Spitak earthquake rupture, 2016 Kaikoura rupture). Surface expressions can range from single, well-defined fault scarps to multiple parallel scarps, to zones of deformation dominated by folding. Furthermore, reverse faults are frequently blind, meaning that they have no surface expression (E.g. 1994 Northridge earthquake rupture occurred on a fault previously unknown). With increased infrastructural development directly over active faults (e.g. Franz Joseph on the Alpine Fault) it is necessary to better understand the complex behaviours of reverse fault surface displacement.

The Dunstan Fault in Central Otago, New Zealand, exemplifies this complexity. Like many active reverse faults in the region, it is expressed at the surface by multiple parallel fault traces, sometimes spanning a zone up to 2.5 km wide. A key question is whether all traces within this fault zone rupture during a single surface-rupturing earthquake, or if individual traces rupture independently. If the latter, is there a temporal or spatial pattern to these ruptures that could inform future rupture forecasting? Alternatively, what is the likelihood of new surface traces forming in future seismic events?

We present new paleoseismic data from three of the four major traces preserved on the Devonshire fan section of the Dunstan Fault to constrain the timing of past surface-rupturing events on individual traces. This is complemented by high-resolution active and passive seismic reflection data, which contextualises the multi-trace reverse fault system with its subsurface tectonic structure.

These results have implications for our understanding of fault displacement hazard of reverse faults. Current New Zealand Ministry for Environment guidelines recommend a 20-meter fault avoidance zone on either side of an active fault trace, irrespective of fault type. In this study we explore the potential to refine fault avoidance zones for multi-trace reverse faults.

Predictability of soil CO_2 degassing from soil temperature measurements in geothermal settings

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Over the last three decades, the methods and accuracy of volcanic CO_2 degassing estimates from active plumes have significantly improved; however, our ability to measure widespread diffuse CO_2degassing has made comparatively less progress. The standard technique of quantifying diffuse emissions is the accumulation chamber method, with point measurements of CO_2flux made over an area of interest and total emissions calculated using geostatistical techniques. However, the number of measurements in these surveys are often sparse and the survey footprint is usually smaller than the whole degassing region, and thus estimating the CO_2emission rate from a region of interest involves assumptions about the representativeness of the mean flux to the larger area.

To address this issue, this study investigates the relationship between CO_2flux and soil temperatures collected using a range of ground- and aerial-based methods at the Menengai and Waiotapu geothermal fields in Kenya and New Zealand, respectively. Diffuse CO_2emissions were measured using a PP Systems EGM-5 portable gas analyser, and soil and ground temperatures were examined using a soil temperature probe and DJI Mavic 3 thermal drone, respectively. Our results show a correlation between CO_2flux and soil temperature over various scales, with permeability also playing an essential role in the CO_2flux-soil temperature relationship. Using these data, we explore the utility of thermal drone measurements for quantifying diffuse degassing and predicting the locations of high CO_2flux regions in geothermal fields for further ground investigations. We suggest there is potential that remotely acquired temperature data may be used to supplement ground-based soil CO_2studies for better informed and more accurate CO_2flux estimates in regions of widespread CO_2degassing.

Probing the depths of Auckland's Volcanic Field: an integrated geophysical investigation into the intraplate volcanism of Tāmaki Makaurau.

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In 2023 an international team of scientists from China, the USA and Aotearoa, New Zealand, embarked on a multidisciplinary study of the Auckland Volcanic Field (AVF). Roughly one third of the total population of New Zealand lives in Tāmaki Makaurau, Auckland, on top of a young and active monogenetic volcanic field. The origin of the AVF is still largely unknown, other than that it is an atypical intraplate active volcanic field not obviously linked to mantle plumes or tectonic processes. This study supported by the Chinese National Science Foundation, the US National Science Foundation and the Royal Society of New Zealand, so far resulted in new seismic data sets from a dedicated temporary array of 20 broad-band land seismometers and 15 ocean-bottom seismometers. Together with seismic data from the recently expanded national network in the region, we are imaging the AVF from the surface to deep in the mantle with a variety of seismic methods. These structural models of the subsurface will constrain geodynamic modelling, with the ultimate goal to determine if the upwelling responsible for Auckland's volcanoes is driven by local structures in the LAB (edge driven convection) or through other means, and what is - if any - the influence of the subduction zone more than 200 km Southeast of Auckland. In this presentation, we will introduce the overarching goals of the project, the team, and its preliminary results.

Uncovering new low temperature geothermal occurrences in Auckland and North Waikato as part of Decarbonising Covered Crops with GeoHeat

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Earth Sciences New Zealand (formerly GNS Science) leads the project, Decarbonising Covered Crops with GeoHeat, which aims to decarbonise New Zealand's covered crop industry by utilising low-temperature geothermal resources as a renewable, reliable, and cost-effective heating solution. Supported by the Ministry for Primary Industries' Sustainable Food and Fibre Futures fund and delivered in partnership with GeoExchange NZ, Vegetable NZ, and Tomatoes NZ, the project focuses on greenhouse growers in the greater Auckland, northern Waikato, and Bay of Plenty regions.
Our goal is to empower landowners by providing maps of regional to local scale groundwater temperature and flow. We are also developing customisable online calculators to determine financial feasibility of converting greenhouses to geothermal energy.

Rapidly the project found that drillers who encounter warm water have no clear requirement to inform council, and curation of what information is reported is handled differently between councils. This results in low temperature geothermal occurrences being poorly documented and not compiled in an accessible, centralised database. We encourage geologists, geotechnical engineers and landowners to collect and share basic ground water temperature readings to support the development of national databases.

We will share examples of data compiled for the project, with a focus on little known geothermal occurrences in Auckland and Northern Waikato.

Preserving historical seismograms from Taupō unrest in 1964-1965 and 1983-1986

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The Taupō Volcanic Centre (TVC) is New Zealand's most active rhyolitic system and the source of the world's youngest super eruption (Ōruanui, ~25,400 years ago). Episodes of unrest in 1964–65 and 1983–86 were among the more significant since European settlement of NZ and may involve a little understood tectonic component. These unrests happened before the digital recording era and the original seismic records exist only on fragile paper seismograms preserved at Earth Science NZ, Avalon Campus. These records have remained largely inaccessible to modern analysis due to the restricted location, limited cataloguing, and high cost of scanning.

In 2025, a pilot project funded by Geonet was initiated to systematically scan and digitise these historical seismograms. Over 7,000 paper records were processed using high-resolution, archive quality scanning, supported by careful quality control and curation to ensure metadata integrity. The digitised archive now provides a secure, searchable resource that can be shared with the academic community.

The data needs to be vectorised to apply modern seismological methods, such as digital waveform analysis, spectral characterisation, and machine learning approaches to event detection, to study and analyse unrest episodes that were previously constrained to hand-picked earthquake arrivals and analogue amplitude measurements. We hope this will enable re-evaluation of earthquake swarms, temporal changes in seismicity, and their relationship to ground deformation and magmatic processes inferred from other datasets. Critically, these periods represent rare examples of prolonged unrest at a super volcano, and their reanalysis has direct implications for understanding present and future activity at Taupō.

By digitising these records, we aim to preserve a unique scientific dataset of national significance. The project will facilitate opportunities for new collaborations and eventually ensures that historic volcanic unrest episodes at Taupō are integrated into global understanding of volcanic hazards and dynamics of super volcanos.

ENV Particle Analysis Laboratory at the University of Auckland

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The Particle Analysis Laboratory in the School of Environment (ENV), the University of Auckland, offers comprehensive facilities to support teaching and research applications. It houses high resolution instrumentation for analysis of particle size distributions in diverse sediments and other suitable materials. Whilst working in the Particle Analysis Laboratory you will encounter many instruments, preparation techniques and expertise to ensure you gain precise and reliable results.

Sedimentology lab at the University of Auckland

David Wackrow[1]
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The School of Environment Sedimentology Laboratory at the University of Auckland offers many facilities for the study of sediment properties and characteristics. Here a vast array of different instruments and expertise can be found to assist with sample preparation and analysis.
The Sedimentology Laboratory provides a functional and safe environment for both teaching and research.

From lava to learning: designing a human-centred educational game for volcanic hazards in Aotearoa New Zealand

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Volcanic phenomena are a common occurrence within the landscape of Aotearoa New Zealand, and children, a vulnerable group in natural disasters, require knowledge about volcanoes and related risks. Applied games offer a compelling medium to engage learners in understanding these hazards. This contribution illustrates the design process of a digital educational game, Volcano Explorer NZ, a digital game created with and for formal educational settings in Aotearoa New Zealand. The game consists of several minigames, each with specific learning goals, to achieve broad volcanic education and geoscience learning using local and cultural imagery, science concepts, and skills.

We used observations and case studies with student groups of different demographics, and interviews with teachers to design the game and to investigate how games designed with a human-centred focus can foster collaborative play and learning within formal educational settings.
To further this aim, an accompanying teacher guide has been drafted, tested and will be adapted to suit teachers of various age groups in New Zealand. This guide is utilised before and after the game to help the teacher utilise this resource, align it with the curriculum and meet science learning goals. The guide also suggests using out-of-game activities for each minigame that a class can undertake in and out of the classroom to enable the transfer of learning from the digital games into the physical classroom. Results from teacher interviews suggested that this teacher guide helped guide discussions, collaboration, and communication within and outside the classroom.

This work underscores the value of collaborative learning and play through games—not only in supporting children's development but also in enhancing geoscience education. By fostering engagement, communication, and problem-solving, our game-based approach contributes to the learning experiences and advances the design of educational games, with a particular focus on enhancing geoscience education.

Using seismic signals to track moving flows: a case study of the 2007 Ruapehu lahar

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Pyroclastic flows and lahars are rapid mass movements that pose substantial hazards around volcanoes. These flows displace atmospheric air, producing infrasound, and exert force on the solid Earth, generating seismic waves. These geophysical signals can be used to detect, characterise, and track these flows. Previous work at Mt Etna (Italy) used seismic signals to locate a pyroclastic flow and track its movement, with the potential for this method to be operationalised and used in real-time. The method works by performing a grid search over possible source locations and determining the location with the best fit to the observed amplitudes at the seismometer assuming a simple model of seismic attenuation with distance.

Here, we apply this method to the 2007 lahar from Ruapehu to test its applicability in a New Zealand context. We are able to locate the lahar and track its movements down the eastern slope of Ruapehu.

We also examine the 2012 eruption at Te Maari and a debris flow in 2018. Due to the location of these events on the edge of the seismic network, the locations are poorly resolved. This highlights the limitations in this method as well as suggesting potential locations for future seismometers to improve monitoring capabilities for this approach.

Comparing the impacts of ship anchoring on sediment structure and composition in Wellington Harbour/Te Whanganui ā Tara

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Ship anchoring impacts the seabed with direct and indirect implications to the health of the shallow marine environment. Previous research has demonstrated that anchoring can gouge into soft sediment habitats by up to 80 cm, with an average excavation depth of ~30 cm. This study aims to assess the impact of ship anchoring on sediment structure and composition in the Wellington Harbour anchorage, Aotearoa New Zealand. In April 2024, we obtained sediment cores from three sites within Wellington Harbour: a highly disturbed site, a recently disturbed site and an undisturbed site. The highly disturbed site is characterised by substantial morphological roughness in bathymetry data attributed to ship anchoring. The recently disturbed site was the location of a known ship anchoring event that occurred ~1 month prior to sediment core collection. Finally, the undisturbed site was a location of similar depth and oceanographic regime to the other two sites, but with no morphological evidence for anchoring, and outside the primary designated anchorage zone. A suite of analyses have been conducted on the cores such as grainsize, Computed Tomography (CT), water content, total organic matter (TOM), refractory organic carbon (ROC), and downcore chemistry by portable XRF (pXRF). Using the undisturbed core as a reference, disturbance from anchoring shows a statistically significant decrease in overall sediment density, disruption to redox proxy pair peeks in Mn/Fe and Fe/S down core, and a reduced ratio of TOM/ROC in the top 4cm of the sediment profile. This study provides new insights into the role of regular physical disturbance by anchoring gear on soft sediment habitats in the context of an urban harbour anchorage. The results of this study will contribute to a wider understanding of ship anchoring impacts and assist in our understanding of the complete environmental signature of anchoring on the marine and coastal zone.

Exposure of different ethnicities to volcanic ashfall in Aotearoa New Zealand

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All of New Zealand's volcanoes can erupt explosively and have the potential to distribute ash across the country. Ash can be highly disruptive and damaging to human health and critical infrastructure. While the New Zealand volcanology community has done a great job at modelling the likely physical extent of ashfall from future eruptions and quantifying the impact of ashfall on human health and infrastructure, less attention has been given to the demographics of the exposed populations.

Here, we combine deterministic and probabilistic simulations of ashfall modelling with StatsNZ data on population information (ethnicity, age) and LINZ building footprints to calculate the differential exposure of ethnic groups to volcanic ashfall. We first focus on an ashfall simulation of the 17 June 1996 eruption of Ruapehu. For this deterministic scenario, we obtain the following percentages for the exposure ethnicities compared to the nationwide ethnic breakdown.

Ethnicity	Exposed to Ruapehu Scenario	Nationwide Breakdown
European	59.7%	62.4%
Māori	28.3%	14.8%
Pacific	3.8%	7.4%
Asian	7.6%	14.0%
MELAA	0.6%	1.4%

Ongoing work is extending this analysis to a probabilistic ashfall modelling, rather than using a single deterministic event.

Understanding the demographic characteristics of populations exposed to volcanic hazards is essential for disaster preparedness and recovery planning.

A legacy of submarine slope failure in seismic reflection data along the active Hikurangi Margin, Aotearoa New Zealand

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Documenting and characterising past submarine landslides is fundamental to understanding their distribution and frequency through time, and critical to assessing the associated hazard. The widespread availability of marine geophysical data at the active Hikurangi subduction margin, east of Aotearoa New Zealand, provides an excellent basis to map regional trends in landslide occurrence. We present a database that documents mass transport deposits (MTDs) in 30 marine geophysical surveys, encompassing ~45,400 line-km of 2D seismic profiles. We map and characterise 737 MTDs, showing variations in size, location and style of failure, which we attribute to changes in geomorphic setting from north to south. MTDs in the northern Hikurangi margin, characterised by a high taper wedge and seamount subduction, show a broad range in size, with the highest proportion of MTDs displaying blocky or intact internal architecture. The central margin, characterised by lower wedge taper, hosts the most MTDs (51%), albeit with the thinnest (on average) and clustering within interridge basins. The southern Hikurangi margin hosts widespread submarine canyons and the largest (on average) MTDs, based on area and thickness. We demonstrate the importance of seismic archives in providing new insights into MTD preservation and discuss the bias between seafloor geomorphology and subseafloor seismic data in quantifying MTD occurrence. Our findings support the interrogation of the varied and complex causes of submarine landslides along active margins generally, as well as regions prone to cascading geohazards and landslide-induced tsunami.

Designing local Time-Dependent Forecast for tsunami: feedback from end users

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The entire coastline of Aotearoa New Zealand is at risk of tsunamis from local, regional and distant sources. With more than 75% of New Zealanders living or working within 10 km of the coast, tsunami risk is significant. The Rapid Characterisation of Earthquakes and Tsunamis (RCET) research programme is aiming to better understand, mitigate and respond to tsunami events in NZ. Under this programme, a system has been developed to deliver next-generation tsunami early warning products within about 30 minutes of the origin of the tsunami. This system will provide a step change in the amount of information provided in early warning forecasts. It aims to present a forecast of the evolution of the tsunami threat, rather than a static picture of its maximum amplitude. We named this a time-dependent tsunami early warning (TiDeTEW).

One key challenge in developing this tool lies in establishing the rules that link numerical forecasts to end-user early warning products. These rules must be co-created through close collaboration between scientists and end-users, including the emergency response sector and affected coastal communities.

To support the development of these rules, we developed a questionnaire aiming to ensure that the local prototype TiDeTEWs that we have created are relevant, clear, and aligned with end users' needs. We present the results from a survey undertaken this year, based on this questionnaire, which was distributed to a range of end users, including Civil Defence Emergency Management (CDEM) groups, individuals involved in responding to tsunami threats, and others who rely on information from the government or NEMA to support decision making.

Hydrothermal signatures in springs and gases at Taranaki Volcano – Opportunities for geochemical monitoring

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Over the next 50 years, there is a 50% probability of an eruption at Taranaki volcano. Current monitoring relies mainly on geophysical precursors, but changes in spring and gas geochemistry could offer earlier warnings. This study characterizes Taranaki's mineral springs and identifies those most suitable for volcanic monitoring.

Some Taranaki springs have interacted with magmatic fluids at depth. Cold kōkōwai springs, observed at seven mid-flank sites, and warm springs on the ring plain (with historic travertine deposition), display helium and carbon isotopic signatures that overlap fluids and gases from the Taupo Volcanic Zone (TVZ). One kōkōwai location degases copious amounts of CO_2, CH_4, and H_2S with levels reaching 5500, 100, and 2.5 ppm, respectively, in multiGAS measurements — higher than levels typically found downwind of volcanic fumaroles. The isotopic composition of these gases and the hydrocarbon ratios suggest a hydrothermal origin.

Moderately elevated CO_2 has also been detected in several river valleys not associated with kōkōwai springs, suggesting degassing could be widespread. As magma ascends from deep crustal levels to a mid-crustal staging zone, gas concentrations and compositions at the kōkōwai springs are expected to change, perhaps without associated seismic activity. Thus, routine monitoring of selected kōkōwai springs could provide the earliest signals of renewed volcanic vitality.

Other potential monitoring targets include the warm springs on the ring plain (12–31 °C), which have a history of travertine precipitation. These springs have elevated volatile constituents and show strong similarities to arc-type hydrothermal fluids. Though indicating ongoing deep heat and magmatic fluid input, detailed studies of the travertine deposits themselves demonstrate that the precipitating fluid temperatures have not changed dramatically over time, even during periods of heightened volcanic activity. Therefore, we suggest the warm springs are unlikely to offer early eruption warnings and are not recommended as reliable monitoring sites on Taranaki.

Volcanic Lakes in Te Arawa: an iwi perspective

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This talk will provide a trans-disciplinary overview of Te Arawa connections to roto in their rohe, highlighting the deep physical, cultural and spiritual connections between volcanic landscapes and the people who inhabit them. Throughout this talk we will examine the integral role these landscapes have played as tupuna (ancestors) and whānau (family) within Te Arawa narratives and the relationship between people and place in this volcanic setting. We will discuss how this relationship has been impacted throughout time, examining the impacts of land-use change, historical science and the introduction of new species, and the current and future restoration and monitoring initiatives taking place. Finally, this talk will explore how iwi, geologists and environmental scientists can work together to ensure these lakes are protected and thriving for future generations.

Magma depletion: an alternative hypothesis for vent distribution in volcanic fields

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The location of a volcanic vent directly influences an eruption's hazards, intensities, and impact, and this influence is exemplified in distributed volcanic fields. An eruption through water can result in a highly explosive phreatomagmatic eruption, as opposed to an eruption driven only by magmatic volatiles. We look here at long-term probabilistic assessments, the outputs of which inform evacuation plans, the (re)location of vital infrastructure, and inform the placement of early-warning monitoring equipment. Current kernel density estimation methods of future vent locations in volcanic fields assume that locations with more past-vents are more likely to produce future-vents. We examine an alternative hypothesis that an eruption depletes the magma source, causing holes or dips in the spatial density estimate for future vent locations. This is illustrated with the Auckland Volcanic Field, Aotearoa-New Zealand, where both magmatic and phreatomagmatic eruptions have occurred, according to the vent location, with the latter resulting in more explosive eruptions and hence hazard.

Should statistical tools be used to harness the forecasting potential of environmental tohu at Ruapehu, and the Central Volcanic Plateau?

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Accurate volcanic eruption forecasts are vital for emergency management decisions but eruption forecasting is intrinsically uncertain, with uncertainty stemming from the incomplete knowledge of system dynamics through to incomplete and temporally biased eruption records. This lack of data severely hinders out-of-the-box forecasting methods and eruption forecasting continues to show room for improvement.

Through the MBIE grant Matatuhi: Unlocking the forecasting potential of environmental tohu via ensemble systems models, we are travelling a more holistic path using the exemplar of Ruapehu, and the Central Volcanic Plateau. Such an approach is intrinsic to Mātauranga Māori that, moreover, provides an alternative lens on what can be considered data, beyond instrumental readings; knowledge, beyond published papers; and forecasts, beyond probability estimates. The long-lived experiential knowledge of Māori iwi and hapū of the rohe, alongside their well-established environmental monitoring also circumvent otherwise insurmountable problems of temporal-recency, and limited signal scope/focus. We also know that adding more voices with alternate understandings leads to better, more transparent forecasts with accurate descriptions of uncertainty, we just don't yet know exactly how to do it.

Expanded definitions of data and knowledge requires more flexible, adaptable tools to produce robust, user-friendly forecasts of our environmental and volcanic future(s). We present here an example of a statistical tool that may have the potential to incorporate these wider definitions, and in the interest of data sovereignty, present it using simulated data, publicly available indicators (King et al., 2017), and pao (Ngāti Rangi Trust, 2014), and discuss the suitability of statistical models for such concepts.

Under pressure: investigating pore pressure dynamics in sheared natural sediment mixtures

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Pore pressure plays a crucial role in the initiation, mobility, and destructive potential of debris flows. Elevated pore pressure can reduce effective stress, weaken internal friction, and promote rapid flow mobilisation. However, the development and dissipation of pore pressure in natural polydisperse material under shear remains poorly understood.

This study investigates the pore pressure evolution in a 100L drum shearing system, designed to simulate conditions analogous to debris flow motion. Experiments were conducted using blends of of natural, cohesive and non-cohesive, poly-disperse sediments as the solids phase. In systematic series of experiments, the sediments were homogeneously mixed with variable amounts of water across a range of solid concentration and grain size distribution- simulating a spectrum of non-Newtonian sediment-water flows from dilute hyperconcentrated flows to debris flows. The primary objectives were to determine whether pore pressure can develop under shear in these mixtures, and to quantify the timescales over which fluid pore-pressure dissipates diffusively.

A major challenge lies in the measurement of pore pressure in such dense, sediment laden flows. This work describes the development and testing of embedded pore-pressure sensors designed to work for natural, poly-dispersed materials, with the goal of capturing transient pressure signals during controlled shearing events.

Preliminary observations suggest that pore pressures do develop under shear conditions in loosely packed, saturated, natural poly-dispersed mixtures. These findings help validate the experimental approach and demonstrate the feasibility of measuring internal pressure dynamics in debris flow analogues.

Insights from these small-scale experiments will inform the design of large-scale flume experiments, where embedded sensors will be used to capture pore-pressure in scaled debris flow analogues propagating down a flume. The results will contribute to advancing the understanding of internal flow mechanics and improving the predictive models of debris flow behaviour.

Long-duration enhanced earthquake analysis to illuminate faulting and earthquake interactions across the Cook Strait

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Cook Strait and the surrounding Wellington and Marlborough regions form a tectonically diverse and active part of Aotearoa New Zealand monitored by a relatively dense seismic network. The region has hosted several large earthquakes in recorded history and acted as the termination of the 2016 Kaikōura earthquake. Despite these earthquakes and the availability of good long-duration seismic data, there remains significant uncertainty in our understanding of the drivers of seismicity in the region, in particular, the mechanisms of earthquake triggering and nucleation. Studies in other regions around the world have shown that small, previously undetected earthquakes can provide key insights into understanding fault geometry at depth, foreshock and swarm processes as well as triggering and earthquake nucleation.

We have extended a nationwide machine learning earthquake catalogue to detect and locate earthquakes between 2011 and 2018. Our catalogue contains roughly 2.5 times as many events in the region as the GeoNet catalogue as well as high quality locations with reduced uncertainties and an improved magnitude of completeness. Our self-consistent cataloguing methods allow us to investigate temporal variability in earthquake occurrence in the region. Initial investigations into spatio-temporal variations in seismicity in our catalogue reveal a greater than 2-fold increase in seismicity during the Cook Strait Sequence relative to background seismicity. This allows us to shed light on the individual faulting processes taking place but it will also provide insights into how triggering played a role in the sequence particularly between the magnitude 5.7 and 5.8 foreshocks, the magnitude 6.5 mainshock and the following magnitude 6.6 Lake Grassmere aftershock. Furthermore, study of the 2016 Kaikōura sequence will give insight into how large earthquake sequences outside of our region of interest interact with the fault structures in the Cook Strait to induce triggering.

Observations from 20 years of seismic data in Aotearoa New Zealand.

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The nationwide seismic catalogue produced by GeoNet is primarily intended to facilitate rapid hazard communication and response. This emphasis, combined with the heterogeneous nature of the New Zealand seismograph network, can mean that some earthquakes are mislocated or not detected at all. In contrast, regional catalogues developed for research purposes offer a much more in-depth view of seismicity. However, they require additional data and/or manual or otherwise time-consuming analysis that are not efficient or available for a near real-time nationwide catalogue. We have developed and applied a novel automated workflow to generate a research-grade earthquake catalogue for Aotearoa New Zealand that balances the best of national and regional earthquake catalogues. This workflow expands and improves the current catalogue, enabling further research into New Zealand's seismo-tectonic setting and a better understanding of present-day seismic hazard.

Our methodology was able to pick and locate 99.7% of all earthquakes in the GeoNet catalogue between 2001 and 2021. This totals 407,553 earthquakes, and provides systematic and robust location uncertainties. In this presentation we present notable seismic activity to illustrate how this enhanced catalogue can enable improved understanding of seismicity in New Zealand. We discuss our observations of inconsistent changes in location across the spatial and temporal extent of the catalogue, reflecting the unique and diverse tectonic settings of New Zealand. Highlights include the impact of our locations on constraining subduction zone structure, and more accurate characterisation of spatial relationships between earthquake sequences such as during the 2001 East Cape Swarm. At a national scale we calculate the 90% and 95% seismogenic depths. We discuss the agreement of our observations with previous models as well as key regional differences such as around the Alpine Fault and Auckland Volcanic Zone regions where we observe shallower seismogenic depths.

Unlocking New Zealand's landscape: national-scale access to airborne LiDAR

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Airborne LiDAR now covers over 80% of Aotearoa New Zealand, enabling new national scale products that unlock opportunities in how elevation data are accessed and applied. Through the National Elevation Programme, Toitū Te Whenua Land Information New Zealand (LINZ) partners with local councils to acquire, standardise, and openly license these data, making them freely available to the public. The latest data include extensive coverage of remote and previously unmapped terrain, offering unprecedented opportunities for geoscience research, natural hazard identification, geomorphological analysis, environmental monitoring, etc. The new national datasets are transforming how elevation data are used across sectors, supporting better decision-making and deeper understanding of our dynamic landscapes.

Multi-resolution 3D insights into a Pegasus Canyon-hosted submarine landslide, Aotearoa, New Zealand

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Submarine landslides are major agents shaping continental slopes and driving submarine canyon evolution by altering geometry, redistributing sediments, and triggering down-canyon transport. Around Aotearoa New Zealand, bathymetric data show abundant submarine landslide scars within canyons such as Pegasus Canyon, though seismic data reveal fewer preserved deposits. This suggests that high-energy canyon environments may hinder long-term deposit preservation.

In this study, we reconstruct the surface and subsurface morphology of a large landslide scar in Pegasus Canyon. We integrate high-resolution bathymetry and sub-bottom profiles from an Autonomous Underwater Vehicle (AUV) with hull-mounted multibeam and multichannel seismic data. These complementary datasets allow us to examine links between landslide geometry, size, and canyon processes. Results highlight a thick (up to 30 m) sediment drape covering the scar, substantially reducing visible relief and altering landslide volume estimates. Such findings demonstrate how post-failure processes can obscure original landslide dimensions and complicate volume calculations.

Accurate estimates of displaced sediment volume are critical. They inform our understanding of canyon evolution, sediment transport budgets, and natural hazards. In particular, submarine landslide volume directly influences tsunami-generation potential, making precise assessments essential for risk evaluation.

More than 3,000 submarine landslides have been identified offshore Aotearoa, with notable concentrations in submarine canyons. Yet, the relationships between canyon development and landslide activity remain poorly constrained. Our results underscore the importance of integrating multi-resolution surface and subsurface datasets to refine landslide volume estimates and better assess the role of canyon-hosted failures in shaping seafloor morphology and contributing to regional tsunami hazards.

Landslide dams around the world: a new book to prompt research

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Landslide dams, occurring when landslides fully or partially block a watercourse, are often invisible, hazardous cascading phenomena, involving slope and river hydrology processes. Despite the potential consequences, many uncertainties and open questions remain regarding landslide dam formation, breaching, and evolution. A new book, soon to be available in 2026, aims to lay the foundation for future research on landslide dams.

The book includes an openly available compilation of landslide dams around the world, significantly increasing documented cases. For example, in New Zealand, prior research found 232 landslide dams. The updated New Zealand Landslide Dam Database includes 1,036 landslide dams. The global database will allow researchers to analyse landslide dam phenomena in more detail, and with more case study data to work with.

Chapters of the book address regions around the world, including North, Central, and South America, Africa, Europe, Central and Northern Asia, East, South and Southeast Asia, and Oceania. Each includes illustrated case studies and points to unique characteristics of landslide dams in the region. These regional chapters are bracketed by chapters clarifying definitions or landslide-dam parameters, and hazard and mitigation.

The book editors and authors (over 75 authors from around the world) hope to prompt future research on this critically overlooked hazard.

Te Mauri Ihoiho: a culturally based framework for climate change resilience

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Climate change is an imminent threat. But it is also an opportunity for hāpori to understand and adapt with the changing environment. The landscape of the Eastern Bay of Plenty is both dynamic and culturally rich. It is exposed to natural hazards that may impact places of great cultural significance. These features provide a unique opportunity to consider the impacts of climate change in ways that value both Māori knowledge and western science.

With Te Ao Hurihuri Iwi Collective (Ngāti Rangitihi, Ngāti Awa, Tūwharetoa ki Kawerau) leading the project, we have developed Te Mauri Ihoiho framework, a holistic representation of local Iwi and community worldview and values. Through this foundational framework, we interweave Māori and western perspectives on the impacts of climate change - including environmental, community, tikanga and mātauranga. We identify landscape changes that may affect marae, urupā, historic and current cultural sites (mahinga kai, wāhi tapu, wāhi taonga), and other significant changes occurring to awa, ngahere and maunga. This information describes the strength of cultural connection to places and spaces, informing kaitiaki and ensuring Kaitiakitanga management is treasured.

By capturing cultural and social information and combining these with scientific data and environmental insights from Earth Sciences New Zealand, this project ensures a robust and holistic suite of information is prepared and utilised to improve our shared knowledge of climate change. We hope that Te Mauri Ihoiho model will be applied elsewhere and likewise build Māori interest, capacity, knowledge of and response to climate change. This integrated approach to building our collective knowledge underpins and guides our ability to best prepare and comprehensively adapt in a changing world.

Quantitative mechanisms of groundwater level fluctuations under harmonic disturbance: stress-strain evidence in a confined sand layer

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Oscillations, step-like changes and sustained changes in groundwater levels induced by earthquakes have long been investigated. However, most existing mechanisms explaining these changes are semi-quantitative or qualitative, due to incomplete explanations of the response process. This study presents a comprehensive and quantitative analysis of groundwater level fluctuations under controlled laboratory conditions. A metal experimental box was constructed, containing a layer of water-saturated sand beneath a layer of clay and three fully penetrating "wells". The experimental box was fixed on a shaking table to test the effects of harmonic disturbance on the horizontally confined sand layer. Eight shaking table tests were conducted at frequencies ranging from 0.5 to 2 Hz and acceleration amplitudes from 0.05 to 0.45 g. Real-time changes in acceleration, pore-pressure and water level were observed using sensors installed in various parts of the experimental apparatus. Shear stress and shear strain behaviors manifest the characteristic relations of sediment deformation during progressive deformation and water level fluctuations. The findings show that shear-strain thresholds trigger pore pressure evolution, resulting in variations in water level. Specifically, shear strains between 10-6 to 10-5 initiate oscillation, while those ranging from 10-5 to 10-4 induce monotonic changes. Non-linear relationships between shear stress and shear strain indicate complex deformation in the water-saturated sand layer. The experimental data provide insights into the quantitative understanding of co-seismic water level changes.

Ngā Ara Pungapunga (Pumice Pathways): Partnering with tangata whenua to develop a new low-carbon pumice economic sector for Aotearoa-NZ

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Pumice or "pungapunga" is abundant in the central North Island, particularly in forestry lands owned by iwi settlement trusts. Overseas pumice has been used since prehistory for numerous applications, from durable "Roman Concrete" to modern uses, e.g., in lightweight construction, cosmetics, and polishing. While Māori traditionally utilised pumice for a wide range of purposes, today there are few pumice operations in Aotearoa-NZ. The "Ngā Ara Pungapunga – Pumice Pathways" research programme has been co-designed with Te Pumautanga o Te Arawa Trust to kickstart a new Māori-driven pumice economy. Working closely with governance entities and hapū-whānau of Te Arawa Waka, we use interwoven quantitative and qualitative research methodologies from geosciences, engineering and ecological economics informed by kaupapa Māori to ensure that tangata whenua aspirations around intergenerational wellbeing, kaitiakitanga and leadership are fulfilled in a future pumice economy.

Globally, pumice-cement blends are well-recognised as low-carbon alternatives to Ordinary Portland Cement but have not been used in NZ since the 1970s-80s. Our focus lies on overcoming the challenges that enable NZ pumice to be used as partial cement replacement which can significantly reduce the carbon footprint of concrete and thus contribute to achieving a net zero carbon future by 2050.

However, developing an industry with pumice, which varies greatly due to differing volcanic origins, eruptive styles and age, requires an in-depth understanding of resource characteristics and quality requirements for targeted products/applications. Geoscience expertise is used to establish quantities and properties of available volcanic raw materials in the Te Arawa Waka rohe providing the foundation for matching NZ pumice attributes to high-value applications in close collaboration with engineering.

The vision for this programme is to be a catalyst to reinvigorate and reinterpret historic pumice mātauranga to develop applications that are widely beneficial across Aotearoa-NZ while serving as an exemplar for future Māori-led economic endeavours.

Identification of the precursory scale increase in the Earthquake Catalog of CSEP-China Testing Center

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With the increasing impact of earthquakes on urban societies, identifying reliable precursors has become a key objective in statistical seismology. The precursory scale increase (Ψ) phenomenon, characterized by an upsurge in the rate and magnitude of small earthquakes preceding a major event, has played a foundational role in the development of the Every Earthquake a Precursor According to Scale (EEPAS) model. While the model has demonstrated effectiveness across various global seismic regions, it has not yet been systematically applied in China. This study utilizes the China earthquake catalog and an automated detection algorithm to examine the occurrence of Ψ prior to major earthquakes within the CSEP-China testing region. After conducting catalog preprocessing and identifying target events, we derive empirical scaling relationships linking the magnitude, spatial extent, and time of precursor activity to the magnitude of future mainshocks. These relationships are then compared to those established in other tectonic settings, particularly the original EEPAS scaling parameters. The study also investigates spatial–temporal trade-offs in Ψ identification, aiming to refine the practical implementation of Ψ-based forecasting models in China. Our results offer new insights into the precursory behavior of earthquakes in the region and contribute to the broader effort of improving medium-term earthquake forecasting capabilities.