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MCPs, a new access layer for geoscience data

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As AI agents and large language models become part of our lives, our way of interacting with data is changing. Alongside traditional APIs, the Model Context Protocol (MCP) is emerging as a standard way to expose data and tools directly to AI systems, allowing agents to discover, query, and reason over datasets without bespoke integration work for every application.

Here, we illustrate this concept by presenting a proof-of-concept MCP, built on top of Tilde, GeoNet's data API, as ESNZ's first implementation of this framework for geoscience data. The Tilde MCP integrated to a local AI Agent exposes GeoNet's monitoring data in a form directly consumable by users, either through maps, graphs or analytics, illustrating an alternative to conventional API access. Beyond GeoNet, we are extending this approach across ESNZ's Nationally Significant Collections and Databases (NSCDs). This positions MCPs not as a one-off integration but as a reusable architecture for making Aotearoa New Zealand's nationally significant geoscience datasets AI-ready, one dataset at a time.

We discuss the design choices behind building an MCP server for scientific data, balancing usability for AI agents against cost efficiency, data integrity and reflect on what this pattern could mean for data discoverability and trust as AI tools become more embedded in geoscience workflows.

A spatio-temporal deep learning framework for real-time fault rupture mapping

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Operational earthquake early warning systems such as FinDer and G-FAST have demonstrated the feasibility of rapid fault characterisation from seismic and geodetic data. Both methods are fast and operationally robust at the cost of producing simplified fault representations that limit their ability to capture the full complexity of large ruptures, potentially involving multiple faults and complex slip distributions.

Here we present a spatio-temporal deep learning framework designed to bridge this gap by producing dynamic rupture probability maps directly from nation-wide strong motion waveforms. The model ingests sliding windows of Peak Ground Acceleration timeseries and produces a per-source classification indicating which fault segment is actively slipping as the rupture evolves. By representing both the station network and the fault source geometry as graphs, the model encodes the spatial relationships between sensors and sources, potentially enabling it to resolve rupture complexity at a level of detail not currently available in operational systems.

Training is performed on a synthetic catalogue of over 5,000 events spanning magnitudes Mw 6.0–9.5, generated with the RSQSim physics-based earthquake simulator and PWSim waveform synthesis approach. Early results on a validation set stratified by magnitude are promising, with strong performance on mid-to-large events and along well-instrumented fault systems such as the Alpine Fault and the Marlborough region. Key challenges remain and include the severe class imbalance inherent to fault rupture detection, spatial over-prediction for smaller events, and the current absence of attenuation constraints that limit performance for large offshore earthquakes.

Future directions include fault-system-specific models, that exploit the geometric regularity of individual fault systems, the introduction of temporal context through a prediction history mechanism and the integration of realistic noise in the dataset to eventually test the model on historical sequences in a near future.

Updated coseismic deformation field of the 2016 Kaikōura Earthquake using multi-sensor InSAR data

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The 2016 Mw 7.8 Kaikōura earthquake ruptured more than a dozen faults across in the upper South Island, making it one of the most structurally complex earthquakes recorded anywhere. We present updated three-dimensional coseismic displacement field for the earthquake, built by jointly inverting six independent Sentinel-1 and ALOS-2 satellite tracks, comprising ascending and descending InSAR and pixel-offset measurements, using a weighted least-squares approach. This yields the most complete satellite geodetic dataset assembled for this event to date, and substantially improves resolution of north–south motion, historically the weakest component in InSAR-based studies, particularly across the near-field rupture zone. The resulting deformation field images the surface expression of this multi-fault rupture in fine detail: up to ~7 m of uplift and ~7 m of southward displacement across the Papatea Block, ~10 m of fault-parallel displacement along the Kekerengu Fault, and previously unresolved ~4 m of sinistral slip on the Snowgrass Creek Fault, which we show connects northward into the Clarence Fault. Compared against independent GNSS observations, our updated coseismic model outperforms all previously published SAR and optical displacement solutions, with RMS residuals of 0.61 m (east), 0.56 m (north) and 0.49 m (vertical), and correlation coefficients of 0.90, 0.98 and 0.78 respectively. These results offer a much-improved observational basis for reappraising source and slip models for Kaikōura, work that is already underway, and for investigating mechanical interactions among the many faults that ruptured. More broadly, they provide a foundation for understanding multi-fault rupture behaviour and seismic hazard across the Marlborough Fault System and New Zealand's plate boundary zone.

Coupled thermo-fluid-mechanical modelling of magma recharge and reservoir deformation using multiphysics

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Understanding how small-volume magma reservoir pressure develops over time and produces surface deformation can provide useful information about subsurface magmatic processes. Many existing volcano deformation models simplify magma injection by applying pressure directly at the reservoir boundary, without explicitly modelling the dynamics of magma intrusion and its rheology and temperature. This study employs a 2D thermo-fluid-mechanical model to simulate magma injection into a crustal reservoir and the response of the surrounding host rock. The model combines laminar magma flow, heat transfer, solid deformation and fluid-structure interaction. The host rock is represented as a viscoelastic material with temperature-dependent viscosity, allowing its mechanical response to vary with temperature and time. Magma recharge is simulated using a time-dependent injection condition followed by a post-injection period. Parametric simulations examine the effects of injection duration, injection rate, reservoir temperature and magma compressibility on reservoir pressure and surface deformation. The model is used to investigate how magma recharge, thermal conditions and crustal rheology together influence the magnitude and spatial pattern of volcanic deformation. It also allows deformation during active magma recharge to be compared with deformation that continues after injection due to viscoelastic relaxation. The model will be applied to the 2022 unrest episode at Ruapehu volcano to evaluate whether the lack of deformation can be explained by magma recharge processes, including the effects of injection dynamics, thermal conditions and viscoelastic relaxation within the crust.

Hidden unrest at Ruapehu: How seismic velocity changes highlight deformation beyond GNSS detectability

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During the 2022 unrest at Ruapehu, New Zealand, seismic velocity decreased while volcanic tremor and Crater Lake temperature increased. No clear coherent deformation transient was detected by the GNSS network. Here we investigate whether an inferred subsurface perturbation could remain below geodetic detection limits. A two-dimensional coda-wave sensitivity-kernel inversion was applied to ambient-noise seismic velocity change measurements to map the unrest related elastic response. The inversion recovered a broad velocity reduction zone on the northeast flank of Ruapehu, covering approximately 35 km² with a mean (dv/v) of about -0.40%. Repeated inversions and synthetic recovery tests supported the northeast sector while indicating kilometres uncertainty in its precise location. The network-averaged velocity reduction of -0.26% corresponds to a reference equivalent pressure perturbation of approximately 11.2 MPa, with Monte Carlo sampling yielding a median of 14 MPa and a 5th–95th percentile range of 6–22 MPa. Mogi detectability modelling showed a compact equivalent source of approximately 0.70 km while remaining below the adopted GNSS displacement limits. These results do not support a discrete spherical pressure source. Instead, they demonstrate that the observed seismic velocity reduction and absence of coherent GNSS deformation are compatible. The findings highlight the value of combining seismic and geodetic observations when monitoring laterally distributed or geodetically subtle volcanic unrest.

Glacial geomorphology and sedimentology of the Poulter/ Waimakariri confluence

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The glacial history of the Waimakariri Valley has been the subject of several studies, but the Poulter Valley which is a major tributary has not been studied since the late 1970s, or as part of a large-scale project to map the glacial geomorphology of the Central South Island. Since then, the availability of high-resolution LIDAR data has enabled mapping at significantly higher resolution than was previously possible.

Using this dataset a range of glacial, fluvial, and hillslope landforms were mapped. Several site visits helped to refine the remote mapping and identify key sediment outcrops which were logged and described. Together, these data allow us to better understand the glacial history of the Poulter Valley.

This detailed mapping revealed a succession of glacial positions, and complex interactions with the adjacent Waimakariri Glacier. A previously undescribed proglacial lake, which formed behind the latest moraine of the Poulter Glacier was identified in the sedimentology. A system of glacial-marginal meltwater channels formed at the foot of Mount White, migrating toward the present-day river channel as the glacier retreated, exploiting the gullies between its lateral moraine ridges. Fluvial and other paraglacial processes continue to dissect the remaining glacial landforms to produce the landscape we see today.

Testing New Zealand's rapid earthquake response tools with complex multi-fault ruptures

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Modern monitoring capability has increasingly shown that many large magnitude earthquakes involve rupture on multiple fault structures and systems, with recent examples including 2024 Noto, Japan; 2023 Kahramanmaraş, Syria-Türkiye; 2021 Mendocino Triple Junction, California; 2021 Haiti; 2016 Kaikōura, New Zealand. Rupture complexity can include spatio-temporal variations in mechanism, rupture speed, slip and geometry. Multi-fault ruptures are also a feature of the synthetic seismicity generated by earthquake simulators such as RSQSim.

Such scenarios are therefore becoming an important component of seismic hazard forecasting and calculation of potential impact. For rapid science advice to support response decision-making, it is also necessary that we understand how our real-time analysis tools will perform for such complex events. Through the Rapid Characterisation of Earthquake and Tsunami Endeavour research programmes a number of real-time analysis tools targeted at larger magnitude earthquakes have been implemented for New Zealand, to complement the standard methods running within the GeoNet programme. Here we explore the capability and performance of some of the real-time analysis tools through the use of real and synthetic examples of multi-fault ruptures.

Cross-hazard AI for transferable, physically informed and decision-relevant forecasting

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Artificial intelligence (AI) is increasingly used to anticipate natural hazards, yet operational adoption remains constrained by limited event data, weak generalisation, limited physical interpretability, and evaluation metrics disconnected from real-world decisions. These challenges are especially relevant to Aotearoa New Zealand, where volcanism, flooding, and increasing wildfire risk threaten communities, infrastructure, ecosystems, and the economy. Our programme develops cross-hazard AI for eruptions, floods, and wildfires, extending from forecasting to warning communication, decision support, and protective action.

For floods, we developed a physics-informed LSTM embedding storage-discharge dynamics into streamflow models. It improves hourly predictions in 99% of New Zealand and 91% of Great Britain catchments, but offers little benefit at daily resolution, showing that physical constraints are most effective when processes are resolved at the modelling timestep.

For eruptions, our transfer-learning analysis of 41 events at 24 volcanoes shows that seismic precursors can be shared across volcanic systems. Models trained without target-volcano data achieve skill comparable to locally tailored models. A cost-loss framework further shows that precautionary use of imperfect forecasts could reduce avoidable losses by approximately 30–90%, highlighting the importance of avoiding catastrophic misses rather than simply maximising accuracy.

For wildfires, our sub-hourly machine-learning forecasts improve skill over an operational fire-behaviour index by 10–30% and approximately double potential economic savings. We also transfer interpretable model-response functions onto climate projections to map future fire-growth probability across New Zealand.

Our programme further extends into human-centred AI, evaluating large language models for testing emergency messages and translating official multi-hazard information into personalised, actionable guidance, validated against public responses and post-event evidence.

Our work is forming the foundation of a multi-hazard forecasting laboratory connecting predictive AI, physical understanding, impact assessment, and warning communication. We are developing open-source methods, datasets, and evaluation frameworks to support decisions from the first detectable signal through to protective action.

Machine and deep learning prediction of missing sonic log data with blind-well validation

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Incomplete well-log suites can restrict quantitative petrophysical interpretation. This study evaluates machine learning and deep learning approaches for predicting missing sonic log data using commonly available well-log measurements from Waikato, New Zealand. Gamma ray, bulk density, deep resistivity, and neutron porosity were used as predictor variables, with DT as the target. Six data-driven models were tested: Random Forest (RF), Extra Trees (ET), XGBoost, k-nearest neighbours (KNN), an artificial neural network (ANN), and a long short-term memory (LSTM) network.

The models were trained using data from two nearby wells, Beckett-2 and Renouf-3, and independently tested on the unseen Rangiriri West-1 well to assess their ability to generalize beyond the training dataset. Blind-well validation showed that LSTM achieved the best overall performance, with an R^2 of 0.8997, RMSE of 5.2151 µs/ft, MAE of 3.8762 µs/ft, and Pearson correlation coefficient (r) of 0.9509. ANN provided the second-best performance, followed by KNN, XGBoost, Random Forest, and Extra Trees. Following validation, the developed models were applied to reconstruct the missing DT log in Blair-1.

The results demonstrate the potential of data-driven methods for reconstructing missing sonic measurements in incomplete well-log datasets. Among the approaches evaluated, the sequence-aware LSTM model showed the strongest generalization performance, highlighting the value of incorporating vertical relationships within well-log data when reconstructing missing petrophysical measurements.

New insights into the early eruptives of the Mangaone Subgroup, Ōkataina Volcanic Centre, New Zealand.

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The Ōkataina Volcanic Centre (ŌVC), at the northern end of the Taupō Volcanic Zone, is one of New Zealand's active caldera centres, with a history of Plinian activity and caldera-forming eruptions, including the ~54 ka Rotoiti eruption. Following this event, the explosive (and possibly effusive) eruptions that make up the Mangaone Subgroup (MaSg; previously units A-L of Jurado-Chichay and Walker, 2000, JVGR 104, 319), records a phase of frequent eruptive activity at the ŌVC up until ~31 ka. The MaSg has a minimum total bulk volume of ~81 km³, with individual units ranging from 0.4 km³ (Unit H) to 20 km³ (Unit I). However, incomplete dispersal data, ambiguous or implausible vent locations, and unresolved internal stratigraphic complexities have thus far limited understanding of the sequence.

This study presents results of detailed field mapping that resolves inconsistencies in the earlier stratigraphic scheme, yielding an expanded stratigraphic succession in which three additional units are recognised. Preliminary data on dispersal patterns indicate vent positions that are distinct from the NE-SW oriented, Taupō-rift-parallel trends of post-25 ka ŌVC activity from the Haroharo and Tarawera lineations, potentially reflecting control by an older N-S-oriented lineament. Several units record a complex range of eruption styles, from sustained Plinian fall through intra-eruptive pyroclastic density currents to localised phreatomagmatic phases, alongside internal characteristics suggestive of multi-vented activity.

These findings reposition the MaSg as a high-resolution record of successive explosive activity following the Rotoiti caldera collapse, offering insights into the magmatic, tectonic, and volcanic evolution of the ŌVC. Future work will extend granulometric and componentry characterisation across the full stratigraphic sequence, refine isopach-derived volume estimates and isopleth-derived vent locations.

Modelling the signatures of supercritical geothermal resources under thermally-inhibited permeability constraints

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Geothermal systems in the Taupō Volcanic Zone (TVZ), New Zealand, are sustained by large-scale convection of groundwater mainly confined to the brittle upper crust. The depth and temperature of the brittle–ductile transition (BDT) is hypothesised to demarcate the lower boundary of fracture-hosted permeability and hence fluid circulation. As direct observations below 3 km are difficult to obtain, the objective of this study is to test whether temperatures in the upper 2 km of hydrothermal systems are correlated with BDT temperature and could hence serve as a proxy constraint on deep thermal and permeability structure.

This work uses numerical models of hydrothermal circulation that couple Darcy flow and heat transport in a 2D axisymmetric domain. Following the work of Hayba & Ingebritsen (1997) and Scott et al. (2016), we use a logistic/sigmoid model of rock permeability that decreases smoothly across a prescribed BDT temperature range. The models reproduce the expected dominance of fluid convection at shallow depths where temperatures are sufficiently low to not inhibit permeability. A convective-conductive boundary forms at a depth that is self-determined by the system balance between shallow convective and deep conductive heat transfer.

Analysis across a range of model parameters and anisotropy conditions confirms a correspondence between the rock's BDT temperature range and hydrothermal fluid temperatures at 2 km depth. Across a range of BDT temperatures and anisotropy assumptions, we recover a linear relationship between the hydrothermal upflow temperature at 2 km depth and the applied BDT temperature (e.g., 338°C at 2 km depth corresponding to a 400–500°C BDT range). Modelled convection cells range in power outputs from 60 to 285MW, which is consistent with the range of estimates for TVZ geothermal fields. These findings suggest that shallow temperature observations can be used to infer rock rheology and permeability properties in hydrothermal provinces.

The Meroo Meadow Member, a new lowest member of the mid Permian Gerringong Volcanics, southern Sydney Basin: tuffs, dykes and latite and lamprophyre-like flows

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The Meroo Meadow Member, a new lowest member of the mid-Permian Gerringong Volcanics of the southern Sydney Basin, is described here for the first time. It lies within the mid to upper Berry Siltstone, below the Koo Lee Tuff Member, of the Broughton Formation. The member has been found south of the presently known flows, along the escarpment from Meroo Meadow, north of Nowra, where the deposits and flows are the thickest, hence the type section location, with more distal exposures at locations to the north and northeast. This new member comprises at least 8 flows and many tuffs, a few distal red sandstone beds and at least two dykes, all previously unreported. The flows are up to 1m thick but usually less than 30cm, and comprise basalts and latites, mostly with petrographic features typical of the lower Gerringong Volcanics, but including an unusual lamprophyre-type that contains abundant hornblende, biotite and clinopyroxene phenocrysts. The tuffs are up to 2m thick, or more. Thinner tuffs often have small marine fossils with abundant bioturbation, Cruziana and Zoophycus ichnofauna, indicating a shallow marine, low energy palaeoenvironment. The earliest tuffs appear to be from submarine eruptions, deposited as pyroclastic flows shed off the emerging volcano and onto the seabed. Intraclasts of latite, basalt and trachyte up to ~40cm in size are commonly found as clasts in conglomerate beds. The red sandstone suggests erosion from a subaerial volcano. The eruptions appear to have been sourced from proximal island volcanoes to the south, which later evolved towards the east, whilst the trachyte eruptions were likely more distal, to the southeast. Detritus from these volcanoes inundated the cratonic quartzose sediments previously derived from the west and southwest. Volcanism was therefore the main factor influencing the deposition of the upper Berry Siltstone, occurring earlier than previously recognized.

A reappraisal of the Early – mid Permian structural history of the southern Sydney Basin: ongoing volcanism and loading stresses from the southeasterly Gondwanan subduction.

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Evidence for prevalent volcanism preserved in the southern Sydney Basin sequence during the initial stages of basin deposition in the Early Permian, through to the mid Permian Gerringong Volcanics, indicates that a new structural model for the tectonic history of the southern Sydney Basin is needed. Thin sections of tuffs and intraclasts collected from locations along the coast south of Kiama to Myrtle Beach, just north of Batemans Bay, of all members of the Talaterang and Shoalhaven Groups, were petrographically analysed to confirm tuff field identification and identify evidence for Permian volcanic activity. XRF and XRD analyses were performed on 42 samples which showed that the tuffs and intraclasts range from mafic to felsic, with <40% to >80% SiO2. This volcanic material was most likely sourced from eruptions associated with an orogenic arc to the east and southeast of the basin, in the vicinity of the Currarong Orogen and western Zealandia, along and behind the westerly dipping subduction zone of the southeast margin of Gondwana. This persistent volcanism challenges the currently established “Thermal passive subsidence” tectonic theory for the lower to mid Shoalhaven Group. Instead, loading stresses associated with convergence at the subduction zone to the east were likely fully operational during this period in the basin evolution. The pervasive volcaniclastic material throughout the succession, including the tuffs and intraclasts, in addition to Permian intrusions and deformation structures such as reverse faults, is therefore used to propose an alternative model for the tectonic history of the southern Sydney Basin, involving loading from convergence rather than passive thermal subsidence. Moreover, in the south, similar stresses associated with the same subduction zone probably occurred during the onset of basin formation, also challenging the current theory for rifting during the initial stages of basin evolution.

Establishing regional Quaternary stratigraphic terminologies to support detailed geological work in Aotearoa New Zealand

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The nationwide QMAP 1:250,000-scale geological map uses a climate-chronostratigraphic framework for most Quaternary deposits, differentiating units according to depositional environment and the Marine Oxygen Isotope Stage timescale, with numbered stages prefixed by Q (Rattenbury & Isaac 2012; NZJGG). While ideal for 1:250,000 geological maps, providing inter-regional context and national consistency, limitations of this approach for more detailed geological mapping include reliance on age inference with little direct dating, and how to deal with Quaternary deposits not depicted on QMAP due to being too thin or insufficiently extensive.

Detailed geological mapping (e.g. 1:50,000 or better), and uptake of geological information by users, especially geotechnical practitioners, would benefit from stratigraphic terminologies readily enabling Quaternary deposits to be classified in the field at all scales. For example, lithofacies-based frameworks emphasise depositional environment and composition with less focus on age and provide stratigraphic context and associative relationships that aid prediction of adjacent ground conditions.

A lithofacies approach was piloted for non-volcanic Quaternary strata in the Auckland area (Barrell et al. 2021; GNS SR2020/05). Takaanini Formation comprises six lithofacies-based members identified via local names with type sections, encompassing organic-rich deposits (Ardmore Member), sandy or muddy coastal deposits (Curlew Member), shelly coastal deposits (Ōtāhuhu Member), landslide-disrupted materials (Kepa Member), local-source alluvial deposits (Pahurehure Member) and distant-source alluvial deposits (Puketoka Gravel Member). Used in the Pukekohe 1:50,000 geological map (Bland et al. 2023; GNS Geol Map 12b), this framework is suitable for further subdivision and application at various scales, including site-specific.

A similar framework for Dunedin (Ōtepoti Group; Barrell et al. forthcoming) is applicable to the southeast South Island, within a proposed South Island regional Quaternary stratigraphic framework based on differing influences on Quaternary deposition of tectonics, fluvial/glacial processes, continental shelf geometry and eustatic sea level cycles. Potential for a comparable North Island framework is being evaluated.

Elucidating the enigmatic: a new geothermobarometer for investigating alkaline basalt magma storage depths

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Thermobarometers elucidate the architecture of volcanic plumbing systems, with melt-thermobarometers particularly useful for investigating the final depth at which magma was at equilibrium before being mobilised for imminent eruption. Current implementations are not, however, reliable for alkaline systems, resulting in the continuing blind spot concerning storage depths and conditions for, as an example, the intraplate Auckland Volcanic Field.
We carried out 23 melt-equilibrium experiments on a piston cylinder at KU Leuven and the University of Liege, using nepheline to alkali basalt rock powders from the Auckland Volcanic Field. Experimental conditions ranged from 5–24 kbar and 1060–1300°C. We combine these new experiments with a dataset from122 alkaline basalt experiments, saturated in olivine-spinel-clinopyroxene ± plagioclase, ± magnetite/ilmenite, compiled from the LEPR database and the wider literature, to derive a new liquid barometer through linear regression.
Our testing thus far indicates that this new barometer has a Mean Average Error of 0.9 kbar, and Root Mean Squared Error of 1.3 kbar. We further test our alkaline melt-barometer on well-studied Icelandic volcanic systems from Iceland's flank zones (e.g. Snaefellsnes, Eyjafjallajokull, Katla, Vestmannaeyjar). Results from our new equation are within error of storage depths estimated by other petrological modelling methods applied to these systems, and geophysical evidence.

We then apply our melt-barometer to Auckland Volcanic Field. We successfully elucidate storage depths for 14 Auckland volcanoes, the medians for which range from 12 to 18 kbar (~36–54 km). This supports earlier interpretations that magma erupted in the Auckland Volcanic Field rises directly from storage in the mantle.

Ashes to answers, fingerprinting fragmentation in Hunga's ~1100 CE vs 2022 eruptions

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The particle morphometry and damage fractures of glassy ash grains record information about fragmentation during volcanic eruptions. Particle shape is heavily influenced by eruption style, while fracture types and abundance record specifically the amount and rate of energy expenditure by different fragmentation mechanisms.

We present analyses of 24 new samples from eruption deposits around Hunga volcano, Kingdom of Tonga, collected during the VEERI-H 2025 voyage on the RV Investigator. Piston cores and multicores collected during the voyage, sampled deposits from both the recent 2022 eruption, and the last large, caldera-forming eruption from Hunga which occurred ~1100 AD.

For each sample, high magnification and high-resolution images of 50–80 4-phi ash particles, were captured with the Backscattered Electron Detector of a Zeiss FEG-SEM. From these, the damage fracture type and abundances are categorized, and an overall Damage Fracture Intensity (DFI) score produced. Samples that represent episodes of fuel-coolant-interaction have a high average DFI, those produced primarily by magmatic fragmentation have a low DFI. Quench granulation creates a population of particles with sub-equal amounts of particles with high and low DFI scores. Images are subsequently used for 2D morphometry analyses of particle silhouettes.

These new samples from both Hunga eruptions are compared with previously analysed material from well-studied eruptions and fragmentation experiments. With this approach we demonstrate the joint roles of fuel-coolant-interaction and quench granulation for both of these large eruptions from Hunga volcano.

School education for natural hazards and risk: lessons from a Tairāwhiti landslide context

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Prior research has shown that school education about natural hazards has many benefits. Education creates a pathway to teaching rangatahi about hazards, risks and mitigation. This learning can then be transferred to wider Whānau, Hapū and marae, as students take information they have learned and share it, providing greater community awareness, and improved preparedness.

We undertook a qualitative study, interviewing teachers and parents/caregivers, to understand how school visits from physical and social scientists benefitted students and the wider community in Tairāwhiti. School visits were conducted with: Te Kura ā-Iwi o Torere, Te Kura ā-Iwi o Te Whānau ā-Apanui, Te Kura Mana Māori o Whangaparaoa, Te Kura o Pōtaka, Te Kura Kaupapa Māori o Kawakawa Mai Tāwhiti, Te Waha o Rerekohu Area School, Te Kura Kaupapa Māori o Te Whare Tāpere o Whātonga, Te Kura o Hātea ā-Rangi and Elgin Primary School. Information provided by visiting scientists included geoscience information about landslides, how to recognise them and signs that one might occur, and to how to prepare, plan, and respond. Information was provided in a range of formats (talks, books, hands-on activities, exercises).

The information delivered provided multiple benefits. First, it raised awareness of hazard, risk and preparedness. Building upon this, it prompted discussions both within the classroom and with wider Whanau, raising awareness at home about risks and what could be done to mitigate those risks. In some cases, students and families became more prepared (e.g., being able to identify landslides in their local area, organizing preparedness care bags). Activities also reduced student anxiety and improved coping, by helping understand how and why landslides occur and providing a practical mechanism for addressing the hazard/risk. Benefits were found to be broader than the education provided, assisting students to develop life skills in responding to adverse events, that were beyond landslides themselves.

Developing distributed acoustic sensing (DAS) methodologies for noisy geothermal environments to characterize the brittle-ductile transition Zone.

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Global renewable electricity demand is surging, and harnessing deeper superhot geothermal resources offers a transformative, low-carbon way to generate continuous baseload electricity. Initiatives like Aotearoa-New Zealand's DeepHeat Programme aim to unlock this potential by investigating fluid movement within the complex brittle-ductile transition zone and reinforce national energy resilience. Distributed Acoustic Sensing (DAS) presents a valuable opportunity to detect microseismicity and other small-scale changes in these geothermal fields through the use of high-density sensor arrays. However, developing new ways of using DAS to detect small earthquakes in a noisy geothermal environment is critical. This upcoming doctoral research will evaluate multiple DAS array configurations at the Rotokawa geothermal field, focusing specifically on developing the data processing methodologies required to isolate subtle signals from a noisy surface environment. By conducting a comparative analysis across these distinct geometries, the project aims to outline the relative advantages, disadvantages, and sensitivities of different processing approaches for resolving low-magnitude events. Ultimately, refining these signal processing workflows for geothermal settings helps maximize the utility of DAS, providing a more nuanced understanding of the geomechanical processes occurring within the brittle-ductile transition zone.

The GeoNet citation landscape: understanding and improving GeoNet data citation practices

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Data citation is an integral part of the scientific ecosystem, and especially for an institution such as GeoNet. Consistent, high-quality citations benefit everyone. For data users, they support findability and reproducibility. For GeoNet, they provide important insights into our user community and their needs, enabling us to better support and develop our services. Since many of our datasets and services are taxpayer funded, tracking the usage of our data is also vital for demonstrating the value of these resources to the scientific community and to New Zealand taxpayers. Proper citation also encourages FAIR data principles: making data more Findable, Accessible, Interoperable, and Reusable.

This poster explores the state of GeoNet's data citations: how our data is being cited, and how citation practices have evolved over time. We track the uptake of updated citation styles and the introduction of Digital Object Identifiers (DOIs), highlighting the shift from informal or missing references toward standardised, traceable citations. We also examine the broader usage and impact of GeoNet data, including the geographic and institutional origins of publications and research.

Proper citations and attribution are one of the easiest ways to help us help you, and to support the critical science that our data enables.

Characterising the brittle-ductile transition beneath the Rotokawa geothermal field using joint seismic and magnetotelluric interpretation

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Superhot geothermal resources, hosted near or below the brittle-ductile transition (BDT), can provide up to three times higher production enthalpy than conventional geothermal fluids. New Zealand's supercritical resource base could support up to 2000 MW of generation capacity, potentially meeting up to 35% of national electricity demand by 2050. This positions superhot geothermal as a major contributor to New Zealand's electricity supply, offering continuous, dispatchable baseload power as demand grows. This potential is contingent on resolving the BDT's structure and physical properties, since its depth and geometry are hypothesised to exert primary control on where superhot fluids can be accessed. The Rotokawa geothermal field is a strong target for superhot geothermal exploration due to its high regional heat flow, but the structure of the BDT below it remains poorly constrained, with considerable uncertainty in its depth and how it varies across the field.

This project aims to characterise the natural behaviour of the BDT beneath Rotokawa to inform superhot geothermal exploration. A new seismic node array will be deployed across the field, and the resulting dataset will be processed alongside existing magnetotelluric data to characterise the structure and properties of the BDT. Jointly interpreting these two independent datasets will allow us to resolve BDT depth and geometry with greater confidence.

The resulting characterisation will directly support New Zealand's DeepHeat Programme's assessment of superhot geothermal potential within the country and improve confidence in future exploration.

Where is the Alpine Fault locked? GNSS analysis of late interseismic deformation across the Alpine Fault

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The Alpine Fault is a major continent–continent, obliquely convergent strike-slip plate boundary which poses a significant seismic risk to central and southern New Zealand. Paleoseismological evidence indicates the Alpine Fault is late in its typical <300-year seismic cycle, estimated to have a 75% likelihood of rupturing in a major earthquake (Mw8+) in the next 50 years. The point of slip nucleation in a future Alpine Fault earthquake, and the distribution and directivity of the slip that follows, will strongly control the distribution and severity of ground shaking. Developing a more detailed understanding of how strain is currently accumulating and where slip is likely to occur in a future large earthquake is therefore essential to improve current seismic hazard modelling.

Over the past 25 years, geological, geodetic, seismological, and thermal-structure studies have provided detailed insights into Alpine Fault kinematics, with recent models suggesting coupling depths of 8.5–22 km that vary along strike. This research aims to further constrain deformation in the Central South Island (CSI) and identify locked zones along the Alpine Fault by calculating geodetic velocities using continuous and campaign Global Navigation Satellite System (GNSS) measurements and fault-slip inversion. Unlike previous datasets, the recently completed 2025 GNSS campaign in the CSI provides a 7-year (2018–2025) dataset with little to no contamination from significant earthquakes, reducing the need for coseismic corrections.

Our preliminary velocity estimates agree well with previously published velocity fields and clearly reveal shear motion across the Alpine Fault, with velocities decreasing systematically with distance from the fault when expressed in a fixed-plate reference frame. These results will form the basis of inversion modelling to quantify fault coupling. The results of this work will contribute to an improved understanding of present-day locking along the Alpine Fault and enhance seismic hazard assessment for New Zealand.

Controls on gallium as a biosignature: insights from Icelandic hot springs

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Several studies on trace element enrichment in siliceous hot spring deposits (sinter) have pointed to gallium (Ga) as a robust biosignature with high preservation potential (i.e. association with microbial silicification within sinter). Confirming the co-association of trace elements and microorganisms in sinter requires examining their relationships across a wide range of geological settings. Most research thus far focuses on rhyolite-hosted geothermal settings such as Yellowstone National Park (YNP) and the Taupo Volcanic Zone (TVZ), mainly using sinter deposited from alkali-chloride fluid chemistries. Acid-sulfate fluid chemistries and iron-rich host rock (e.g. basalt-hosted geothermal areas) are lesser studied depositional environments that may also enrich Ga. Iceland is ideally suited to continue the study of trace element biosignatures in such settings. These basalt-hosted, commonly acidic hot springs may be particularly relevant in astrobiology, as siliceous deposits identified on Mars may originate from areas with similar fluid chemistry and host-rock.

This study, focusing on Ga, uses sinter samples gathered from geothermal areas across southern Iceland. It utilizes petrography for textural sinter classifications, alongside synchrotron X-ray fluorescence (sXRF) for elemental mapping, micro-X-ray diffraction (μXRD) for silica phase identification, and Ga K-edge X-ray absorption near edge structure (XANES) for assessing Ga coordination and oxidation states. These techniques can be compared to recent YNP and TVZ studies, and will constrain the role of host-rock composition and fluid chemistry on Ga abundance, and enrichment relative to microorganisms. Thus, these results will expand the application of Ga as a biosignature in ancient hydrothermal deposits from Earth and Mars.

Testing reworking sources for Marlborough's apparent radiolarian K/Pg survivors

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Thirty years ago, biostratigraphic analysis of diverse radiolarian assemblages from the Mead Hill Formation in Marlborough found minimal extinction during the Cretaceous/Paleogene (K/Pg) mass extinction. Such high survivorship has not been found in other sites around the world, including other high latitude localities. This observation led to the hypothesis that the Marlborough 'Cretaceous survivors' are the result of persistent reworking over 1–2 million years. Southern Marlborough is a potential source area where the top of the Mead Hill Formation is an unconformity and uppermost Cretaceous strata were eroded prior to or during the earliest Paleocene.

For the present study, samples were collected from four sites in southern Marlborough (Puhi Puhi River, Jordan Stream, Waipapa Bay, and Kaikoura Wharf) to determine whether southern Cretaceous assemblages align with the Paleocene 'Cretaceous survivor' assemblages in sites to the north. Intra-bed variation in radiolarian assemblages and sedimentary structures from newly collected Paleocene Woodside Creek samples were also analysed to determine if anomalously high persistence of Cretaceous taxa relative to other Marlborough sites is due to their redeposition within sediment gravity flows. Radiolarians were extracted here using hydrochloric acid for carbonate lithologies and a recently developed method for chert and siliceous lithologies using heated sodium hydroxide rather than the traditional method of processing such samples with extremely hazardous hydrofluoric acid.

We find that the southern sites lack the diverse nassellarian fauna typical of northern 'Cretaceous survivor' assemblages and are thus unlikely to be the source for reworked faunas in the north. The northern 'Cretaceous survivors' are either reworked from another source (most likely the northern margin of the Chatham platform) or true survivors that were isolated within post-extinction refugia.

Landslide mapping within Auckland's northern Future Urban Areas

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Rapid expansion of Auckland, New Zealand's largest city, into designated Future Urban Areas (FUA), including Silverdale-Dairy Flat-Wainui and Kumeū-Waimauku, will soon see tens of thousands of new residents and associated infrastructural and industrial development in previously rural areas. Bedrock geology of these areas includes variably volcaniclastic Early Miocene alternating sandstone-mudstone turbidites (Waitematā Group) and Cretaceous–earliest Miocene deep-marine sedimentary strata and oceanic basalts (Northland Allochthon). Both units are predominantly engineering weak rocks and have propensities to slope instability. Sand-dominated Quaternary aeolian deposits are widespread in the west; these typically poorly consolidated engineering soils are also prone to slope instability.

Pre-development landslide mapping helps reduce landslide risk by identifying and delineating areas characterised by slope instability, thereby helping inform land-use management, planning, and infrastructure development. When applied optimally, this supports informed choices about where best to undertake land-use intensification, and the design of remedial and other measures to reduce risks, ultimately reducing exposure of people and assets to landslide-related damage.

LiDAR-based geomorphological and geological mapping across 1182 km² of northern Auckland, including FUA, has identified >7000 existing, largely pre-historic, landslides. Association is indicated between bedrock geology and landslide occurrence. Most mapped landslides are in areas underlain by Waitematā Group, with the largest (up to ~1 km across, 767,000 m² extent) associated with thick, conglomeratic slope-canyon turbidite fills (Cornwallis Formation / Helensville Conglomerate). Landslides are common but generally smaller in areas underlain by Waitematā Group's East Coast Bays Formation alternating sandstone-mudstone, and on relatively steep slopes formed on Quaternary aeolian sand deposits. Landsliding on low-angle failure planes typifies fine-grained Northland Allochthon strata. Collectively, these observations highlight associations between the important roles that variable lithification and grainsize may play in failure mechanisms and landslide size.

Preliminary observations from LiDAR-derived surface-difference maps and InSAR data show that several of these landslides are active

New insights into the geology of the Kumeū-Silverdale area (northern Auckland)

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'Geology of the Kumeū-Silverdale area' is a new 1:50,000 geological map for the northern Auckland area, covering 1182 km² between Muriwai, Devonport, southern Kaipara Harbour and Ōrewa. Led by Earth Sciences NZ and predecessors within the government-funded Urban Geological Mapping Project (RGMAD Nationally Significant Database and Collection), it is part of the first concerted geological and geomorphological mapping campaign in northern Auckland for >20 years. The map's focus is providing detailed geological information for planning and other purposes in an area where urbanisation is rapidly expanding into previously rural areas and where infrastructure investment is substantial and likely to increase. Additionally, the map area has experienced many landslides during recent large-scale weather events.

Geological mapping has been undertaken in close partnership with geomorphological mapping of the area, drawing heavily on several regional-scale LiDAR surveys and other information resources such as orthorectified aerial photograph mosaics and borehole databases.

The main geological units are deep-marine Early Miocene Waitematā Group (Warkworth Subgroup) sedimentary rocks and Waitākere Group volcaniclastic rocks, and Cretaceous–earliest Miocene deep-marine sedimentary strata and oceanic basalts (Northland Allochthon). Quaternary sand-dominated Āwhitu and Karioitahi Group aeolian deposits are widespread in the west.

The main features of this geological map include:

- Higher-resolution mapping of the area's geological units, underpinned and complemented by detailed geomorphological mapping.
- Much-improved integration of geophysical (particularly LiDAR), geomorphological, and sub-surface (borehole) datasets.
- A mapped distribution of geological units that is significantly more consistent with landscape features.
- Differentiation of constituent lithostratigraphic sub-units within the geotechnically problematic and somewhat enigmatic 'Northland Allochthon' and associated Waitematā Group rocks in the Silverdale-Dairy Flat area.
- Recognition of more than 7000, largely prehistoric, landslides up to ~1 km across and 767,000 m² in extent, several of which are active. There is high-level correlation between bedrock geology and landslide occurrence.

Seismic attenuation informs the presence of melt and fluids under the southern Central TVZ (Taupō-Reporoa)

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The southern central TVZ is the locus of a number of high-temperature geothermal systems characterised by very shallow (~6 km deep) seismic-aseismic depths, implying unusually shallow brittle-ductile transition zones in these systems.

We develop a high-resolution 3D model of seismic attenuation, a rock physical property that is sensitive to porosity, fractures, temperature and the presence of fluids, melt. To do so, we use well-constrained hypocentre locations for 2009–2020 (Bannister et al., 2025) and existing GeoNet picks. Using a machine-learning model, we detect additional P and S arrivals from a dense (~5 km spacing) temporary seismograph deployment recording in 2009–2011 from Taupō to Reporoa. We subsequently invert for P and S t* from earthquake waveforms, which are input to a tomographic inversion.

The resulting model provides unprecedented resolution of attenuation (1/Q) properties to depths of 10–15 km. Results reveal a thick, near-surface layer of low Q (high attenuation) associated with volcaniclastic sediments, which provide a sharp contrast with moderate Q values indicative of relatively intact greywacke basement. Beneath the Rotokawa–Ngā Tamariki geothermal field, the basement overlies a pronounced low-Q zone below 6 km depth, interpreted as the presence of small amounts of melt and/or fluids and reflecting a particularly shallow brittle-ductile transition. A dipping low-Q feature extending toward the surface suggests enhanced fracturing related to faulting and fluid circulation within the greywacke basement.

The Q model is compared to an independent MT resistivity model that is also sensitive to high-temperature fluids and melt in the crust. The complementary nature of both models enables more robust interpretations.

Road construction through a caldera rim

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The reconstruction of State Highway 5 in the 1970s required some engineering solutions, which had to deal with the legacy of the 240,000-year-old Rotorua caldera eruption. Thus, eruption left a number of challenging and unique ground conditions, which had to be investigated and then designed, leading up to the construction contracts.

These site features are: 98°C ground conditions, thixotropic boiling mud, the proximity to three fault lines, as well as effects due to varying lake levels.

This site is adjacent to the conference venue so would lend itself to an onsite visit, utilizing the pedestrian underpass built into the more recent construction of the Old Taupo Road SH5/ SH30 intersection roundabout.

Crystal in a haystack: searching for mid-Cretaceous zircon in the Otago Schist

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Recent U-Pb detrital zircon data from the Otago Schist have yielded anomalously young mid-Cretaceous maximum depositional ages, implying that terrane accretion via underplating continued later than previously recognised. While these data have important implications for terrane architecture and metamorphic processes in the Otago Schist, the prevalence and spatial extent of the mid-Cretaceous protolith signature remain unclear.

This study presents exploratory U-Pb detrital zircon data from Otago Schist samples collected from the Rock and Pillar Range, Dunstan Mountains, Pisa Range, and Wānaka, to assess the spatial extent of the mid-Cretaceous protolith. Preliminary results are consistent with previous studies and suggest that the distribution and/or exposure of mid-Cretaceous Otago Schist protoliths may be extremely limited. Zircon crystals typically display complex internal zoning which in some cases has resulted in mixing of age domains during LA-ICP-MS analysis, emphasising the value of trace element signatures for the interpretation of U-Pb zircon dates.

Characteristics and evolution of a volcaniclastic fluvial-lacustrine system in the Hamilton lowlands, New Zealand.

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Hamilton Basin has been influenced by tectonic, volcanic, and sedimentary processes that are well-understood at a regional scale. However, events that shape the subsurface geology and geomorphology at a local scale remain poorly understood. To resolve this uncertainty, we reconstruct and interpret the geological and geomorphological evolution of a farm-scale site just south of the confluence of the Waikato and Waipā rivers, near Ngāruawāhia.
Analysis of a LiDAR-derived digital elevation model identified features that guided further investigation. Nine sediment cores, ground-penetrating radar, and electrical resistivity surveys constrained subsurface sediment distribution and enabled these features to be related to their surface expression. Facies analysis of the cores, combined with radiocarbon dating and tephrochronology, supported interpretations of depositional environments and geological history.

Results reveal a mid-Pleistocene to Holocene geological history dominated by volcanic, fluvial, lacustrine, and geomorphic processes. A prominent hill, the oldest landform in the area, includes a ~5 m-thick ignimbrite that outcrops near its base. Deposition of volcanogenic alluvium (Hinuera Formation), associated with the high-energy, braided, ancestral Waikato River, formed the surrounding plain. A particular 100 m-wide, geomorphic feature with 2 m relief, extending east-west across the farm, was underlain by a succession of predominantly coarse sands and interbedded sandy clay and clay, which coincided with a geophysical anomaly in this depth range. Sediment in cores adjacent to this feature were generally finer-grained. A blocked-valley riverine lake co-existed with this sedimentary environment, in which organic-rich, lacustrine muds accumulated, until the lake drained toward the Waipā River via a nearby gully system between ~14.0 and 11.3 ka.

By linking surface landforms and underlying sedimentary records, this study provides a detailed reconstruction of a volcaniclastic fluvial-lacustrine system and therefore contributes to the wider geological history inferred for the Hamilton Basin.

From slope to scalable data product: Earth Sciences NZ’s approach to developing and deploying advanced data pipelines for nationwide landslide forecasting.

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Taking machine learning (ML) and scientific modelling workflows from a research/development stage to deploying them robustly at scale is a significant challenge. Hurdles such as data accessibility, multi-dataset integration, model reproducibility/cataloguing, and computational resource requirements are all frequently encountered and cause operational deployment to be often the most time consuming/high effort part of the data/ML pipeline lifecycle. Here we present two examples of ESNZ data pipelines focused on delivering national data products for both slow- and fast-moving landslides. We'll walk through the model development and deployment stages to showcase the challenges we faced and the engineering/tooling we adopted to overcome them.

Mapping natural hazards for public understanding: current lessons from the Natural Hazards Portal

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Natural hazard maps carry significant responsibility. They can help people understand the places where they live, work and visit, but they can also be misinterpreted as predictions, property assessments, or definitive statements about future damage. The Natural Hazards Portal is a public-facing platform developed by the Natural Hazards Commission Toka Tū Ake to make natural hazard maps and claims information easier to find, understand and use.

The Portal brings together information about natural hazards in Aotearoa New Zealand and presents it for a broad public audience. Its users include homeowners, property market professionals, journalists, researchers, insurers, planners and local government staff. These audiences bring different levels of technical knowledge, different needs, and different expectations of what a map can tell them. This creates a central challenge: how can complex natural hazard datasets be made accessible to a wide public audience, without making them seem more precise and certain than they are?

This presentation will share practical lessons from the Portal's redevelopment, with a focus on designing public-facing hazard maps for non-specialist audiences. Drawing on user research, stakeholder engagement and implementation experience, it will discuss approaches to plain-language legends, multi-hazard map design, mobile usability, data provenance, caveats, and the balance between accessibility and appropriate caution. The presentation will highlight considerations that may be relevant to others communicating natural hazard information to the public.

Long-term magma recharge and top-down triggering of the 2022 Hunga eruption

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The 15 January 2022 Hunga eruption was one of the most explosive volcanic events of the last century, providing an exceptional opportunity to investigate how magma reservoirs evolve prior to catastrophic eruption.

We use clinopyroxene crystallochemistry, thermometry, diffusion chronometry, and geochemical modelling to reconstruct the pre-eruptive evolution and timescales of magma storage and recharge beneath Hunga volcano. Composite zoning in clinopyroxene records repeated interaction between hot, primitive Mg-Cr-rich recharge magmas and more evolved Mg-Cr-poor resident magmas within a long-lived, chemically heterogeneous crustal reservoir. Trace element modelling indicates that clinopyroxene fractionation was the dominant control on incompatible trace element variations, whereas Cr variability primarily reflects repeated mixing between primitive and evolved magma compositions. Diffusion chronometry reveals multiple episodes of crystal remobilisation and magma recharge spanning months to centuries before eruption. Importantly, the diffusion records provide no evidence for a renewed deep mafic intrusion immediately preceding the climactic eruption. Instead, repeated recharge progressively introduced heat and primitive melt into the shallow system, conditioning and priming the reservoir over extended timescales.

We propose that the final destabilisation of the system was driven not by a discrete pre-eruptive mafic intrusion, but by rapid decompression and evacuation of an already primed shallow reservoir. The Hunga eruption therefore demonstrates how long-term, episodic magma recharge can progressively prime a caldera system, while catastrophic eruption may ultimately be initiated by rapid decompression of the shallow reservoir.

Maunga-led geoeducation research: efforts to enhance students' science identity and sense of place around Ruapehu

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On the road leading to Tūroa Ski Field, at the base of Ruapehu, sits the Ngāti Rangi Office. From the frequent visit of tourists seeking information emerged the vision for the Southern Gateway, an idea to transform this space into a place visitors and local iwi can use to learn and appreciate aspects of whakapapa, pūrākau and mātauranga of Ngāti Rangi. A partnership between Ngāti Rangi, the University of Canterbury and local educators sparked the opportunity for new educational research centred on Ruapehu. In this project, we are co-developing place-based bicultural geoscience educational resources focused on the maunga. These resources comprise a series of videos, where Ngāti Rangi stories underscore important features and geoprocesses in the area. These videos, together with learning activities and an interactive display in the office, integrate a place-based virtual field trip. Place-based designs are characterised by the presence of authentic learning experiences and content that, where possible, promotes sustainable practices and strengthens participants' relationship to place. Therefore, our goal is providing useful tools to foster the connection between students/teachers and the places surrounding them, as well as promoting the development of their identity as "science people". As part of the co-creation process, local educators have been consulted and interviewed about their curricula needs, and how themselves and their students relate to science. Our research is investigating the impacts of these resources by surveying students and teachers on their science identity, sense of place and perceptions about scientists. Student perceptions will also be explored using the Draw-A-Scientist Test and Checklist to examine persistent stereotypes of scientists. As resources are currently under development, this presentation will focus on the co-development process, underlying theoretical approaches, curricula needs and science identity of teachers, and the sharing experiences that contribute to broader conversations on developing locally grounded learning resources.

Embracing uncertainty: an open-source workflow for geothermal reservoir modelling

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Geothermal exploration and reservoir management rely heavily on three-dimensional subsurface geological models, which are incorporated into numerical fluid flow simulation models, and used to support drilling decisions, resource assessment, and field development. These models are commonly derived from a single geological interpretation, despite significant uncertainties arising from variable data quality, coverage, and conceptual understanding of the subsurface. Capturing and communicating this uncertainty remains a key challenge for geothermal modelling and decision-making.

Here, we present a workflow that incorporates geological uncertainty directly into geothermal reservoir models using open-source tools. Geological models are developed in GemPy, a Python-based geological modelling code that facilitates generating multiple geologically plausible subsurface realisations from the same input. These realisations are then used in Waiwera heat and mass transport simulations to explore the influence of alternative geological interpretations on predicted fluid flow and reservoir behaviour.

The workflow is evaluated using case studies from the Taupō Volcanic Zone (TVZ), spanning both regional-scale settings constrained by sparse datasets, and geothermal field-scale settings informed by detailed geological data. These ‘end member’ models allow assessment of the suitability of GemPy for representing the structurally complex volcano-tectonic environments characteristic of the TVZ. Ongoing work includes investigating minimum data requirements, model resolution and scale effects, representation of stratigraphic and structural complexity, and the methodology for generating multiple geological realisations for uncertainty analysis.

The results of this study have potential applications for both conventional geothermal exploration and reservoir management, and the emerging field of deep, superhot geothermal exploration, where the high cost and risk associated with deep drilling demand the most robust possible understanding of subsurface conditions. Beyond resource development, the workflow may also provide new insights into the complex interactions between magmatic, tectonic, and hydrothermal processes in the TVZ and have applications in minerals and hydrogen research.

An updated 3D regional basement model of the Taupō Volcanic Zone, New Zealand

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The Taupō Volcanic Zone (TVZ) hosts Aotearoa's largest geothermal resources and is one of the world's most active silicic volcanic provinces. Understanding its subsurface structure is critical for geothermal exploration, reservoir modelling, and an improved understanding of the tectonic and magmatic evolution of the region. This study presents an updated 3D geological model of the TVZ basement and major fault framework developed in Leapfrog Energy.

The model extends from the Bay of Plenty coast to the southern limit of the TVZ and is a substantial update of earlier interpretations. It integrates recent geological, geophysical and geothermal datasets, including updated gravity surveys, seismic refraction constraints, geothermal drilling information, mapped faults and caldera boundaries. A simplified regional fault network was developed from the New Zealand Community Fault Model to provide a structurally coherent framework suitable for regional-scale numerical modelling of geothermal fluid flow and heat transport.

A key component of the study is the development of a residual gravity anomaly to basement-depth relationship. Independent drillhole and seismic constraints were used to derive best-fit functions that estimate basement depth across areas lacking direct subsurface control. The resulting model provides a consistent regional representation of inferred basement morphology to approximately 3 km depth.

The model captures the current understanding of the structural architecture of the TVZ while remaining adaptable to future advances in geological and geophysical knowledge. Emerging interpretations of buried caldera systems, improved imaging of deep crustal structures, and forthcoming data from deep geothermal exploration programmes, including superhot geothermal initiatives targeting basement rocks, are expected to further refine future iterations.

The resulting model provides a regional framework for geothermal exploration, reservoir characterisation, fluid-flow simulation, geodynamic modelling, and future geoscientific investigations across the TVZ. It establishes a foundation for integrating new datasets and improving understanding of the links between tectonics, magmatism and geothermal systems.

Impacts of Tropical Depression 5F in the north of the Gisborne/Tairawhiti Region

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A severe storm struck the Gisborne/Tairawhiti region over the 20th to 22nd of January 2026. The storm resulted in significant impacts in the northern parts of the region with landslides and debris floods resulting in multiple dwellings being severely impacted and the area isolated as a result of damage to State Highway 35 and local roads. In addition, a large number of landslides occurred across the region and large woody debris influxes from both indigenous and exotic forest areas occurred.

Impacts of the storm were exacerbated by 2 storms that impacted the region in the preceding month. Three-day rainfalls in the worst affected areas ranged from 316 to 401mm but peak rainfalls accumulated over a 10-to-13-hour period with hourly peaks ranging from 29mm to 47mm/hr.

To date 6500 landslides have been mapped in areas where we have acquired post-event drone maps, high resolution LiDAR and aerial imagery, and lower resolution Pleides Satellite imagery. It is hoped to obtain further imagery over critical areas soon or use AI enhanced Sentinel 2 for key areas.

The impacts on the ground were severe and the potential for loss of life was higher than Cyclone Gabrielle but fortuitously no lives were lost. There were, however, many close calls. Seventeen dwellings were red placarded due to landslide damage and a further 28 properties with reduced damage were yellow placarded. For every one of those placards there is a family whose lives have been permanently disrupted. At a community level, the future looks bleak and it is possible that there are areas where it is just too risky for dwellings to remain. After Cyclone Gabrielle, there was the FOSAL process to deal with managed retreat, that option is not on the table for tropical Depression 5F.

GeoNet data collection from sensor to cloud

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GeoNet operates a nationwide network of geophysical instruments supporting real-time monitoring of earthquakes, volcanoes, tsunami and land deformation across Aotearoa New Zealand. Recently the communications and data transportation elements of this network have undergone a redesign with particular attention towards being cloud-oriented.

This poster will highlight the main goals of this redesign and its implementation. This includes the design of a resilient, secure and affordable communications network. The technology decisions will also be explored, as well as the communication services and mechanisms used within the network.

The redesign was partly built as a response to the GeoNet processing and collection platforms moving away from in-house and hosted infrastructure, to being fully in the cloud. Although GeoNet has utilised cloud hosted services for a long time, this redesign is the first major push towards getting the raw sensor data delivered into the cloud directly.

The resulting cloud architecture will be presented along with examples of real-time data collection of seismic and GNSS data.

Currently the GeoNet network consists of over 2000 devices deployed at more than 600 sites throughout the county and surrounding regions. The upgraded network design presented here is key to maintaining this level of converge while keeping within the constraints of the GeoNet Programme. The updated networks are also crucial in continuing to provide robust data feeds for research and response. The mechanisms for accessing these publicly available datasets will be presented.

Earthquake interactions on the Marlborough Fault System before the 2016 Kaikōura earthquake.

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2016 hosted two M>7 earthquakes in New Zealand, the Te Araroa M7.1 earthquake north of East Cape in September 2016 and the M7.8 Kaikōura earthquake. Previous work has shown that the Kaikōura earthquake modulated the aftershock sequence of the Te Araroa earthquake. Using a dense catalogue of >50,000 earthquakes constructed using high-resolution earthquake detection methods applied to both data from the permanent GeoNet network and data acquired from a regional deployment run by DPRI, we show that the Te Araroa earthquake generated enhanced seismicity on the Marlborough Fault System in the months before the Kaikōura earthquake, but did not result in significant triggering of seismicity on the faults that ruptured in the Kaikōura earthquake.

Our catalogue shows (a) long-lived, complex seismicity around the transition between the Fowlers Fault and Clarence Fault; (b) clustered seismicity around the edges of Hanmer basin; (c) extensive seismicity on the Humps Fault near the nucleation point of the Kaikōura earthquake punctuated by small swarms, without significant changes in earthquake rate in the weeks prior to the Kaikōura earthquake; (d) extensive triggered seismicity on the Awatere Fault following the Te Araroa earthquake; (e) limited seismicity on the Kekerengu Fault, but some triggered seismicity on the Clarance Fault and Fidget Fault.

A hybrid GMPE–machine learning approach for rapid PGA and MMI prediction for Earthquake Early Warning in New Zealand

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Earthquake Early Warning (EEW) systems require rapid and reliable estimates of ground shaking at locations where warnings are needed during an earthquake. This study presents a hybrid ground-motion modelling approach for rapid prediction of peak ground acceleration (PGA) and Modified Mercalli Intensity (MMI) from crustal earthquakes in New Zealand.
The framework combines a ground-motion prediction equation (GMPE) logic tree derived from the New Zealand National Seismic Hazard Model (NSHM 2022) with machine-learning residual correction to improve regional ground-motion prediction. GMPE calculations are restricted to source, site, and distance parameters that can realistically be available or approximated within an operational EEW system. Source parameters include earthquake magnitude, epicentral location, focal depth, and an estimated focal mechanism, while site conditions are represented using Vs30-based information. New Zealand Community Fault Model (CFM) information is incorporated to represent regional crustal faulting characteristics. The analysis uses 62,076 ground-motion records from 1,768 crustal earthquakes spanning reported magnitudes from 3.4 to 7.8. At this stage, the study uses final GeoNet-reported earthquake location, depth, and magnitude as source inputs; uncertainty associated with real-time estimation of these parameters is not propagated. Model performance was evaluated using event-based cross-validation to assess generalisation to previously unseen earthquakes.

The GMPE-only baseline produced an ln(PGA) RMSE of 1.060 and R^2 of 0.573, with PGA expressed in units of g. The hybrid CFM-based approach reduced RMSE to 0.756 and increased R^2 to 0.783, representing a 28.7% reduction in RMSE. PGA predictions were subsequently converted to MMI using a New Zealand ground-motion-to-intensity relationship. The hybrid model achieved an MMI RMSE of 0.662 and MAE of 0.488 MMI units, compared with an MMI RMSE of 0.924 for the GMPE-only baseline.

These results demonstrate the potential of combining physics-based ground-motion modelling with machine-learning residual correction to improve rapid shaking estimates for EEW in New Zealand.

Shallow shear-wave structure revealed by dense SAHKE arrays across the southern North Island, New Zealand

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The southern North Island of New Zealand lies above the strongly coupled southern Hikurangi subduction zone, where a significant proportion of plate motion is accommodated within the overriding Australian Plate. This deformation is expressed by active fault systems in the Wellington and Wairarapa regions, posing substantial seismic hazard. While surface geology and crustal-scale structures are relatively well constrained, the shallow subsurface (<2 km depth) remains poorly resolved despite its importance for earthquake ground motions and basin amplification effects.

We use seismic data acquired during the Seismic Array HiKurangi Experiments SAHKE (2009–2010) and SAHKE-II (2011) experiments together with ambient-noise interferometry to construct a high-resolution 2-D shear-wave velocity (Vs) model across the southern North Island. The exceptionally dense SAHKE-II array, with average station spacing of <150 m, enables recovery of short-period Rayleigh waves (>0.05 s) that are sensitive to structures in the upper ~1.5 km. Rayleigh-wave dispersion curves derived from ambient-noise cross-correlations were inverted using a Bayesian approach to obtain 1-D Vs profiles and associated uncertainty estimates, which were combined to produce the 2-D velocity model.

Vs increases from <1.4 km s^{-1} near the surface to ~1.8–2.0 km s^{-1} at depths approaching 1 km. Velocities are generally higher in the western part of the transect than in the east. Alternating high- and low-Vs anomalies occur along much of the profile, with a persistent low-Vs zone beneath the Wairarapa Valley. Several velocity contrasts coincide with mapped reverse faults, suggesting that shallow fault-controlled structure exerts a strong influence on near-surface seismic properties. These results provide an improved framework for ground-motion simulations and refined assessments of seismic hazard in the southern North Island.

Calibrating fault rupture signatures in on-fault lakes using the 1888 Amuri Earthquake

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Small lakes located directly on active faults have considerable potential to preserve precisely dated records of surface-rupturing earthquakes, but exploiting these archives requires understanding how a known earthquake is expressed in the sedimentary record. We investigate the sedimentary response of two small lakes situated directly on the Hope River Segment of the Hope Fault to the 1888 Amuri earthquake, which produced approximately 2 m of surface displacement in the vicinity of both basins. Sediment cores from Horseshoe Lake and Lake Lorraine were analysed using sedimentological observations, computed tomography, physical and chemical sediment properties, and sedimentary DNA. These analyses reveal distinctive event deposits associated with the most recent surface-rupturing earthquake. The deposits record multiple processes generated by intense near-field shaking, including simultaneous sediment failure and seiche-induced reworking of both allochthonous and autochthonous material. Radionuclide and radiocarbon chronologies constrain these deposits to the 1888 earthquake. The historical 1888 rupture provides a natural calibration experiment for determining how surface-rupturing earthquakes are recorded in small on-fault lakes. Characterising the processes and sedimentary signatures associated with this known event provides criteria for identifying older earthquake deposits and establishes the basis for extending high-temporal resolution Hope Fault earthquake histories beyond the instrumental and historical period.

Supporting geoscience decision-making under uncertainty: Bayesian networks and a global community of practice

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Geoscience decisions are often made in the face of uncertainty, incomplete data, evolving evidence, and complex interactions between physical, environmental, and social systems. Bayesian networks (BNs) provide a flexible probabilistic modelling framework that enables the integration of diverse information sources, including monitoring data, process understanding, numerical models, and expert judgement. Their transparent graphical structure helps make assumptions explicit, supports scenario evaluation, and facilitates the communication of uncertainty to decision-makers and stakeholders.

Applications of Bayesian networks in geoscience are expanding rapidly and include volcanic eruption forecasting, natural hazard assessment, environmental management, ecosystem modelling, water resources, climate adaptation, and risk analysis. By combining evidence within a coherent probabilistic framework, BNs can support both scientific understanding and practical decision-making where uncertainty is unavoidable.

As interest in Bayesian network approaches continues to grow, the Bayesian Network Modelling Association (BNMA) provides an international community of researchers, practitioners, and students dedicated to advancing Bayesian network theory and application. Through webinars, conferences, mentoring, collaborative workshops, and "Bring Your Own Bayesian Network" (BYOBN) sessions, BNMA supports knowledge exchange, skills development, and the sharing of modelling experiences across disciplines.

This poster introduces Bayesian networks and the BNMA community to geoscientists, highlighting how probabilistic graphical models can help bridge the gap between scientific models and decision-making. A selection of case studies from hazard, environmental, and risk-management contexts will illustrate how BNs are used to integrate multiple sources of evidence, formalise expert judgement, evaluate alternative scenarios, and communicate uncertainty. The poster also showcases opportunities for collaboration through BNMA and encourages geoscientists to engage with a growing international community focused on developing transparent, reproducible, and decision-relevant Bayesian network models.

Supporting decision-making in a volcanic crisis: A community approach to developing an unrest model for Taupō volcano

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Lake Taupō, situated in the central North Island of Aotearoa New Zealand, overlies one of the world's most frequently active rhyolitic caldera volcano systems. While its latest major eruption occurred ~1,800 years ago (232 ± 10 CE), unrest episodes, characterised by heightened seismicity and deformation, have occurred repeatedly over recent decades. During the 2022-23 unrest episode, the volcano monitoring team at GNS Science (now Earth Sciences New Zealand), together with university researchers, developed scenarios describing plausible pathways for the evolution of unrest. However, these assessments lacked a formal probabilistic framework to support the evaluation of alternative scenarios and the communication of uncertainty to decision-makers and the public.

To address this need, we have developed a Bayesian Network model to support scenario-based forecasting of volcanic unrest at Taupō volcano. The model has been co-developed by researchers from Earth Sciences New Zealand, Victoria University of Wellington and Massey University, with a strong emphasis on transparency, reproducibility, and usability. The model structure was iteratively refined using empirical data and expert judgment. We use the IDEA protocol (Investigate–Discuss–Estimate–Aggregate) to estimate model parameters, including a calibration exercise to derive performance-based weights for experts. Developing calibration questions has been a challenge because the limited geological record and monitoring data provide few independent questions for expert calibration.

The resulting model will provide probabilistic estimates of alternative unrest outcomes and is intended to assist scenario evaluation and uncertainty communication among volcano monitoring scientists, emergency managers, iwi, and other stakeholders. It will support decision-making under uncertainty, offering a reproducible framework for integrating different data streams and expert perspectives. By embedding transparency and collaboration throughout, this work contributes to a broader effort to make probabilistic models more accessible, auditable, and useful for decision-making in a volcanic crisis.

Monsoon, upwelling, Silicon and Carbon cycling: climate driven interplays in the Arabian Sea up to the last InTerglacial (MUSiC ArT)

Matthieu Civel-Mazens[1], Martin Tétard, Giuseppe Cortese, Joe Prebble, Annachiara Bartolini, Samuel Jaccard, Gregory De Souza
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In the Arabian Sea, the South West Monsoon (SWM) is active during summer and drives the Somali-Arabian Upwelling System (SAUS). The SAUS brings cold, deep, and nutrient-rich water masses to the Indian Ocean's surface, fuelling siliceous microplankton or silicifiers. Silicifiers (mainly diatoms and radiolarians),are an important component of the soft tissue pump, a biological mechanism that lowers atmospheric CO2 concentrations. Despite the key role of this soft tissue pump in monitoring global climate and the socio-economic impacts of the SWM and SAUS in middle East and Eurasia, little is known about the monsoon, upwelling and soft tissue pump variability in strength relative to past climate and how they may evolve in the future due to global warming. To palliate this problem, MUSiC ArT proposes to use state-of-the-art technologies and methods to deconvolute the influence of climate on the SAUS and SWM intensity and associated impacts on siliceous productivity over the last 150,000 years, covering the last interglacial period. The project, funded by a Marie Sklodowska Curie Actions (MSCA) postdoctoral fellowship, aims to carry out innovative micropalaeontological and geochemical analyses on two sediment cores of the Arabian Sea. The presentation will detail the project which will take place from September 2025 to August 2028.

A new molecular fossil record of East Antarctic temperature and vegetation across the Eocene-Oligocene Transition.

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Continental-scale glaciation of Antarctica initiated during the Eocene-Oligocene Transition (EOT; 34.5–33.7 Ma), suggested by climate models to have been driven by the crossing of a critical atmospheric CO_2 (pCO_2) threshold. This "tipping point" response raises concerns about, inversely, potential ice sheet destabilisation as anthropogenic pCO_2 rises. Current model validation of the EOT threshold response, however, is restricted. Existing Antarctic EOT proxy records are incomplete, do not span the full transition period, or have not had newer analytical methods applied to them.

My research generates a new high-temporal-resolution (~160 ka) molecular fossil record spanning the entire EOT from the near-complete western Ross Sea CIROS-1 sediment core. Molecular fossils, or biomarkers, are organic geochemical markers found in sediments that record information about past environmental conditions. I have analysed distributions and compositions of leaf wax-, archaea-, and bacteria-derived molecular fossils within the sediment, applying updated methodology and proxy calibrations. Here, I present preliminary EOT fatty acid and temperature data, and their implications for climatic and environmental conditions over this transition period.

My findings fill a critical gap in the Antarctic molecular fossil record, and promote improved model validation of an Antarctic threshold response to support future projections.

A high-resolution analysis of geomorphic controls on deposition during the March 2007 Ruapehu Lahar.

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On 18 March 2007, the tephra dam at the summit crater lake of Mt. Ruapehu burst, releasing 1.3 x 10^6 m^3 of water, generating a breakout lahar that travelled approximately 200 km down the Whangaehu valley. At Ruapehu, lahars have been prevalent over the last 2000 years and are the most destructive hazard.

Ruapehu lahars are complex, exhibiting variable rheological regimes, with rapid transitions between debris-flow and hyperconcentrated-flow states in response to repeated sediment entrainment (bulking) or loss (debulking), both laterally and longitudinally. Sediment concentration and volume determine flow behaviour, including how far it travels, how destructive it becomes, and where and how its deposits accumulate. Understanding the controls on lahar erosion and deposition is therefore crucial to effectively analyse future hazard impacts.

To capture the effects of the March 2007 lahar, pre- and post-lahar LiDAR surveys were flown and used to generate Digital Elevation Models (DEMs). GIS software was used to examine the geomorphic changes resulting from the lahar, including estimates of erosion and deposition from DEM differencing. The statistical relationships between lahar deposition and other channel parameters, including slope, sinuosity, and channel width was then analysed. Previous statistical studies have investigated channel changes over 1 km stretches; here, higher resolutions are examined. Initial results display cyclical trends in deposition along the channel. Closer investigation of channel characteristic patterns and volumetric change at this scale may demonstrate how erosion and deposition during a lahar event is controlled and how rheological transitions are influenced.

Lahar computational simulation tools currently lack the ability to adequately model erosion and deposition. This research will contribute to improving lahar models, better adapting them to forecasting geomorphic change, and to improving probabilistic volcanic hazard analysis, with potential application to other volcanoes, such as Taranaki, Semeru, and Unzen.

From hazards to adaptation: lessons from Auckland's Shoreline Adaptation Programme

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Across Aotearoa New Zealand, communities and decision-makers are grappling with how to move from understanding climate and coastal hazard risk to making practical, long-term adaptation decisions. With more than 3,200 km of dynamic and varied coastline, Auckland provides a compelling case study of what it takes to undertake adaptation planning at scale.

Auckland Council's Shoreline Adaptation Plan (SAP) programme has developed long-term adaptation strategies for council-owned coastal land and assets, bringing together climate and coastal hazard science, mana whenua iwi values and knowledge, community values, infrastructure and asset planning, and long-term investment considerations.

Lara Clarke was the Programme Lead for the Auckland Council SAP programme, working as part of a multidisciplinary team of planners, coastal scientists, engineers, ecologists, engagement specialists, asset managers and infrastructure providers, alongside mana whenua and Auckland's coastal communities. A planner and climate adaptation specialist, Lara brings experience across GNS Science, research, local government, consultancy and academia, with a particular focus on using natural hazard and climate science in planning and decision-making.

Drawing on the experience of developing the SAP programme, Lara will explore what it takes to move from hazard information to implementable adaptation pathways. The keynote will share practical lessons on working with uncertainty, responding to different knowledge systems and community aspirations, navigating infrastructure and investment decisions, and building processes that can 'adapt' as values and physical conditions change. It will also reflect on what Auckland's experience can offer local government, communities and organisations facing the challenge of turning a knowledge of natural hazards and climate information into adaptation strategy and actions for decisions needed today.

When to 'get gone'? Testing tsunami evacuation map designs, risk perceptions, and warnings

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Tsunami evacuation maps are a key tool used to raise public awareness and preparedness about tsunami risk. They also play an important role in response to early warnings by showing which areas of the coast should be evacuated for life safety in the event of a tsunami threat. Design of public-facing tsunami evacuation maps varies globally in terms of how evacuation zones are conceptualised and communicated. It is unclear how these design differences may affect individuals' understanding and decision-making in response to warnings. Here, we present the findings of a 2021 survey that explores how three common evacuation map styles influence risk perceptions and intended protective actions in Aotearoa New Zealand (n=1,128). We also explore relevant awareness of tsunami risks and warnings. We discuss how the findings underpin new national guidelines for tsunami evacuation zones and how awareness of tsunami risk and warnings have changed over the last decade.

Extracting fire histories from inland dunes: a new proxy of environmental change and human impact

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As the climate warms, wildfires are increasing in frequency and severity. Fire is not commonly associated with arid and semi-arid desert environments, however these regions have a long history of both natural and human burning. Current paleofire records come primarily from charcoal preserved in wetlands, bogs, and lakes. This creates a gap in understanding fire histories of arid and semi-arid environments, where such archives are rare or absent. Patton et al. (2023) developed a new method of reconstructing fire histories using charcoal from coastal dune foot slope deposits. They were able to create a Holocene fire record that matched charcoal records from swamps and lakes in the Cooloola Sand Mass of SE Queensland, Australia. The goal of this study is to use charcoal in dune foot slope deposits in the Channel Country of Queensland, Australia to create a paleofire record, testing the method in an arid inland environment. The Channel Country is comprised of permanent and semi-permanent lakes (referred to as billabongs). Longitudinal (desert) dunes occur within 500m of the lagoon and these dunes provide a target for dune foot slope charcoal analysis. Dune charcoal records will be compared with charcoal records from lake cores, to determine if the dune foot charcoal method is applicable in longitudinal dunes. To achieve this, detailed soil and geochronological investigations will be undertaken. The latest available results will be presented.

Improving extreme wave and wave runup estimates for coastal hazard assessment along the Canterbury coast, New Zealand

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Reliable estimates of extreme waves and wave runup are critical for coastal hazard assessment. We present an updated assessment of wave conditions along the Canterbury coast, focusing on improvements to the wave hindcast, extreme-value estimates, and empirical runup predictions. Wave conditions from the NZWAVE-ERA5 hindcast were evaluated against long-term observations from the Banks Peninsula wave buoy. Consistent with previous assessments, the hindcast underestimated extreme significant wave heights. A distribution-based bias-correction method using satellite observations substantially improved the representation of the upper tail of the wave-height distribution. Extreme wave heights were estimated using peaks-over-threshold analysis and a Generalised Pareto Distribution, extending estimates to annual exceedance probabilities as low as 0.2%. Joint-probability analysis using the conditional extremes approach of Heffernan and Tawn (2004) was used to characterise the dependence between storm-tide levels and wave heights, demonstrating that extreme waves and elevated sea levels do not necessarily occur simultaneously. Wave runup was assessed using 8 empirical formulations for sandy and composite or mixed sand and gravel beaches and validated against available observations of historical events. The validation highlighted substantial variability between formulations and beach types. The best-performing equations were subsequently selected for application in the Canterbury Coastal Calculator.

Mapping a changing mountain landscape: geomorphology and surficial geology of the Aoraki region, central Southern Alps

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Geomorphological and surficial geological mapping provides an essential framework for understanding landscape evolution, natural hazards, and environmental change in rapidly evolving alpine environments. A map and spatial dataset depicting 510 km² of the Aoraki region, central Southern Alps has been compiled to test the process on a landscape undergoing substantial and rapid change. The map represents conditions during 2022–2025 and is suitable for use at scales down to approximately 1:10,000. Interpretation and digitisation were undertaken at approximately 1:5,000 scale across the Hooker, Tasman and Murchison catchments, using aerial and satellite imagery, repeated high-resolution photogrammetric elevation models, and LiDAR data collected between 2008 and 2025.

The GIS dataset uses polygons to represent fundamental geomorphological units including snowfields, glaciers, moraines, talus, outwash plains, bedrock slopes and landslide deposits; polylines to represent features including ridge rents, moraine ridges, trim lines and fault traces; and points for local observations such as orientations of planar structures. A separate polygon overlay provides an inventory of the location and extent of landslides, including source and runout areas, identified between 1993 and 2025. Only landslides expressed in the 2022–2025 landscape are incorporated within the geomorphological unit dataset.

Repeated elevation models also allow the mapped units to provide a framework for quantifying landscape change. Topographic change has been measured for several epochs between 2008 and 2022 using models of difference and feature tracking. These reveal dramatic snowfield ablation and glacier down-wasting, together with widespread landsliding and rockfall. Mean surface lowering of hillslope, talus and landslide units is approximately 0.1–0.7 m/yr. Landslides, rockfalls and rock avalanches have affected approximately 22% (111 km²) of the mapped area since 1993, illustrating both the dynamism of the Aoraki landscape and the value of detailed geomorphological mapping as a spatial framework for monitoring future change.

Examining the impact of coastal volcanoes in the marine environment: a study of the 2008 Chaitén Eruption, Chile.

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While the impacts of terrestrial and marine volcanic eruptions are both well studied, these settings have historically remained independent of one another, with the effects of coastal subaerial eruptions on the marine environment remaining poorly understood. Their influence on sediment transport into and deposition within shallow marine settings such as enclosed gulfs and fjords remains an enigma, but is likely extensive, since these environments act as sediment traps due to restricted circulation in basins. This understudied land-ocean connection is especially apparent where coastal volcanoes with multiple drainage basins and rivers feed into shallow marine environments. Such a setting is exemplified by the explosive rhyolitic eruption of Chaitén Volcano in southern Chile in May 2008, producing widespread tephra fallout, pyroclastic density currents, and forcing the evacuation of Chaitén's ~5,000 residents. Rainfall-driven lahars then followed both the Chaitén and Rayas rivers, washing ~0.5–1.5 x 10^6 m^3 of sediment into the Corcovado and Ancud gulfs, respectively, over 3 days.

In 2024, Schmidt Ocean Institute expedition FKt240902 (Fire & Ice: Volcanic and Glacial Interactions) visited these gulfs and collected 25 sediment cores, bathymetry, and sub-bottom data to help unravel the impacts of the 2008 Chaitén eruption on the seafloor. This research incorporates initial cruise results alongside new sedimentology and GIS analysis. Preliminary results reveal: 1) distinct rhyolitic ash horizons in sequences resembling lahar deposits recorded in distant cores, and 2) a submarine stream network that suggests sediment routing may be directed northwards towards the Ancud Gulf. Refining the extent of marine Chaitén tephra will assist in further examining the effects of ocean-entering lahars on sediment transport and deposition within enclosed gulfs. Unlike in New Zealand, the proximity of Chile's fjords to active volcanoes allows for the direct study of tephra and lahar inputs into marine environments, alongside the examination of coastal-volcanic processes.

History of large submarine eruptions before the destructive 15 January 2022 eruption of Hunga Volcano – preliminary results

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RV Investigator voyage IN2025_V05 (VEERI-HOT) 'Volcanic Eruption and Ecosystem Recovery Investigation, Hunga Observations and Timeline' recovered multicores and piston cores that provide insight to the history of large submarine eruptions before the destructive 15 January 2022 eruption of Hunga Volcano, in the Kingdom of Tonga.

Sediment cores reveal complex 2022 eruption deposit stratigraphy, post-eruption reworked deposits, and pre-2022 primary eruption deposits. Of the 81-multicores and 7-piston cores deployed, 8 recovered pre-2022 eruption deposits with material suitable for dating. Initial C14_AMS dating of planktic foraminifera within the pre-2022 eruption deposits, and from sediments above and below these deposits, indicate there have been at least three prior major eruptions in the last 4150 years. The oldest, which we refer to as the '4K-Ash', has only been recognized in piston core S26_PC01 (~55 km west of Hunga Volcano), where sediments immediately below the ash are dated 2119 ±17 BCE. A distinctive '1K-Accretionary Lapilli Ash' is represented by ~10 cm thick airfall deposits with accretionary lapilli up to 3 cm max diameter, in multicore S03_MC01 (~20km west-HV) where it is dated 946 ±16 CE, and S02_MC02 (~18 km Southwest-HV), where muddy sediment above and below the 1K-Ash are dated 1520 ±15 CE and 192 ±16 BCE, respectively. Mass transport ash deposits (Ash-MTDs) that appear to be associated with the '1K-Accretionary Lapilli Ash' have also been identified in multicore S22_MC02 (~30 km East HV) and S26_MC01 (~30 km West HV). These Ash-MTDs are dated 919 ±16 CE and 961 ±16 CE, respectively. Younger Ash-MTD's have also occur in multicore S02_MC02 (~18 km southwest HV) and S14_MC01 (~80 km Northeast HV). Muddy sediments immediately below these younger Ash-MTDs are dated 1484 ±15 CE and 1520 ±15 CE, respectively.

Pre-2022 eruptive deposits of Hunga Volcano

- 'Ash MTDs' ~500 years ago.
- '1K-Accretionary Lapilli Ash' ~1000 years ago.
- '4K-Ash' ~4150 years ago.

Reconstructing dome-building eruption sequences in the central Taupō Volcanic Zone: an insight into the Korotai pyroclastic deposits

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Rhyolitic dome-forming eruptions occur throughout the cycle of silicic caldera systems, yet the magmatic processes controlling their behaviour remains poorly understood. Following the Whakamaru caldera collapse, over 60 lava domes were emplaced within the northern section of the caldera, forming the Maroa Volcanic Centre (MVC). The MVC contains various pyroclastic deposits, some associated with the onset or explosive destruction of the lava domes, while others have unknown sources, including the Korotai pyroclastic deposits (hereafter Korotai) (283 ± 11 ka). This research explores the formation of Korotai, reconstructing the eruption sequence and identifying a potential source.

Here, we present new field observations of Korotai from two weeks of mapping and stratigraphic log construction, and sampling for rock x-ray fluorescence spectrometry (XRF). Korotai outcrops across approximately 3 km^2, with a preserved volume of less than 1 km^3. Korotai contains multiple deposit types throughout the stratigraphy, suggesting variations in eruption style, including welded and fiamme-bearing ignimbrite, unwelded ignimbrite, and interbedded airfall. The unwelded ignimbrites are 5 to 45 vol.% clasts, supported by an ash matrix. Clasts are dominated by a continuum between obsidian and pumice endmembers, ranging from a vesicular, white, crystal rich pumice, to frothy, black and grey banded pumice, to dense obsidian. Crystalline lava lithics are also observed. We interpret that the abundance of obsidian within Korotai suggests it is associated with a lava dome. A potential source dome has been identified to the north of Korotai.

Preliminary whole-rock XRF data will examine the connection between the identified dome and juvenile and lithic clasts from Korotai. This ongoing research will model the vertical extent of the underlying magma system, using rhyolite-MELTS geobarometry for storage and extraction pressures. Finally, we will evaluate the implications of this research for volcanic hazard monitoring and management within the central Taupō Volcanic Zone.

Beyond the patchwork: seamless 2D–3D seismic integration across the Taranaki Basin

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Seismic interpretation across the Taranaki Basin has long been constrained by a simple fact of acquisition: surveys are shot as postage stamps, restricted by permit or landuse, and stitching them together usually means sacrificing quality to match the weakest dataset in the mix. Yet the prize is considerable. New Zealand's only producing hydrocarbon province, the Taranaki Basin is a ~100,000 km² Cretaceous–Paleogene basin born from the breakup of Gondwana, and a remarkably complete natural laboratory for seismic sequence stratigraphy, capped by a striking thrust-faulted trend along its eastern margin. Onshore and offshore the western North Island, the basin is densely covered by seismic surveys and ~700 wells, many with detailed logs and core; these data are held in confidence by the NZ Government for five years before public release.

At SeisMomentum, we have developed a proprietary technique for merging 2D and 3D seismic volumes while preserving the quality of each input, enabling autotracked interpretation across volume boundaries and through areas where 2D data provide the only connection.

Motivated by industry and academic interest in the Taranaki Basin, we integrated ten 3Ds and thirty-three 2D surveys, equating to 6.25 million input traces, to produce a true basin-scale dataset. The 30GB 3D seismic volume extends from Kapuni in the south to Pohokura in the north and contains 2.5 million traces at 25 x 25 metre resolution.

The regional interpretation of this ‘Taranaki Panorama 3D’ is ongoing, with trending geomorphologies being unearthed, revealing ancient paleogeographic systems and encouraging the addition of further volumes, pushing our computer hardware to the limits.

Pestering the public: a case for regional geological societies

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Understanding how people think about, and engage with, the earth sciences is difficult to grasp outside of direct experience. Natural hazard events repeatedly demonstrate how deeply societal resilience is built on the bedrock of scientific literacy, yet for much of the public this remains a distant and abstract concept.

How, then, do we communicate earth science to communities in ways that build a more resilient nation? This question grows more urgent as the sector faces an ageing workforce and shrinking government investment. The marginalisation of earth science within the new school curriculum threatens to further erode tertiary enrolments, and with it New Zealand's capacity to fill the process-based science roles the country depends on.

Reversing this trend requires enthusiasm, sustained effort, and persistent community engagement. As generational expectations shift, so too must the ways we communicate; this is where regional geological societies have a renewed role to play.

The Taranaki Geological Society is rebuilding with exactly this in mind: strengthening community connection and trialling innovative ways to draw people back into the sciences through real-time engagement with earth processes. This talk offers both a look back and a look forward from 2026, as we consider how to counter the ongoing decline in the earth sciences, and the great mass extinction of science in New Zealand.

Geospatial classifications and benthic geomorphology across Manukau Harbour based on hydrographic survey AU441

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One of the largest natural harbours in New Zealand, Manukau Harbour is the western navigable waterway into the city of Auckland and is one of the great ancestral harbours of Tāmaki Makaurau. Manukau Harbour contains significant morphological and ecological diversity, comprising of large sand banks, mangrove forests, deep channels, and rocky/sandy shorelines within a highly dynamic, tide-dominated environment.

Earth Sciences New Zealand was tasked by Te Kaunihera o Tāmaki Makaurau / Auckland Council to undertake benthic terrain analysis, sediment grain-size analysis and seabed classification of Manukau Harbour using multibeam bathymetry, seafloor backscatter and sediment samples acquired during hydrographic survey AU441 in 2025. Although the AU441 survey data only covers approximately 15% of the harbours underwater area at high tide (54 km2), these data provide significant insights into seafloor morphology, sediment distribution, and hydrodynamic processes.

Results from Benthic Terrain Modelling indicate much of the harbour area consists of flat plains and broad slopes, while greater complexity occurs within tidal channels, rocky areas and sediment-wave and ripple fields. Key features include active scour channels, depositional banks, exposed rocky substrates, extensive bedforms, and a probable landslide south of Cornwallis Peninsula. Benthic Terrain Modelling highlights how narrow channels, steep rocky margins, scour holes, and migrating sediment-wave and ripple fields form a highly heterogeneous seabed across the surveyed area. Detected movement of seabed ripples and wavefields also shows that parts of the harbour floor change significantly over periods of days. Here we present an overview of the AU441 bathymetry dataset, extracted geospatial derivates and models, and contextualise these results to the local geological/hydrodynamic setting.

Integrating legacy fault databases: new opportunities for seamless onshore-offshore fault hazard research in Aotearoa New Zealand

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With the recent amalgamation of GNS Science and NIWA to form Earth Sciences NZ, new opportunities were identified for integrating existing authoritative datasets from each legacy agency. The onshore NZ Active Faults Datasets (previously published and maintained by GNS Science) and offshore Geological Structures Database (previously maintained by NIWA) were identified as key complementary datasets that could be progressively integrated to provide additional value to fault hazard research across New Zealand. Through establishing a unified framework and platform for presenting active fault data across New Zealand, opportunities to improve confidence in fault trace continuity across the coastal zone, identify gaps and inconsistencies in existing interpretations, and support future national updates using common standards and version-controlled workflows have been identified.

As in most cases of integrating legacy databases, such a task is not as simple as merging existing interpretations into a seamless data product. Both legacy databases were generated to meet very different scientific and operational objectives, using different mapping methodologies, classification schemes, spatial resolutions, data sources, and attribute structures. Consequently, the integration of these databases into seamless and complimentary onshore-offshore active fault datasets requires multiple steps of data transformation, interpretation reconciliation, and quality assessment to ensure compatible and consistent outcomes for both current and future users. Here we provide a progress-to-date overview of the onshore-offshore fault database integration exercise, highlighting the opportunities, challenges, and future directions (e.g., inclusion of other fault datasets) for combining legacy active fault datasets.

Seabed 2030: pushing the needle towards 100% ocean mapping

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The Nippon Foundation-GEBCO Seabed 2030 project has been tasked with building a seamless map of the world's oceans by 2030. Now in its 10th year, Seabed 2030 has facilitated significant investments into the necessary technical, scientific, and management frameworks to compile all available seabed mapping information. Since its inception in 2017, the global bathymetric ocean mapping coverage has increased from ~6% to more than 28% in 2026, representing more than 90 million km^2 of mapped seafloor; the equivalent of mapping ~60% of Earth's land area.

Facilitating the Seabed 2030 project are five data centres across the globe. The Pacific Ocean Centre (POC), hosted by Earth Sciences New Zealand, has one of the largest continuous stretches of the world's oceans to compile data for, as well as some of the deepest ocean trenches. Through collective action by local/international governments, the private/commercial sector, NGO's, philanthropic entities, and the research sector, the POC has seen significant advances in new seafloor data being added to the GEBCO grid since 2017. Here we showcase the work of Seabed 2030, updates from the POC, and how users can access new multi-resolution bathymetry data from the recently updated GEBCO download portal.

Stress and locking of the Puysegur Subduction Zone: observations from over 30,000 earthquakes and outstanding questions

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Quantifying the degree of coupling between the overriding and subducting plates at subduction zones is important for improving our understanding of seismic and tsunami hazard along these compressional margins. In Aotearoa New Zealand, the Hikurangi Subduction Zone is well-studied, and as a result, several locking models of the plate interface have been developed. In contrast, a quantitative analysis of plate coupling along Aotearoa New Zealand's southern subduction zone, the Puysegur margin, is lacking, limiting our understanding of seismic and tsunami hazard for this region.

We present data from our five-year-long PTANGO (Puysegur Tremor and Nucleation Geophysical Observatory) earthquake catalogue, containing over 30,000 earthquakes and place them into the context of coupling along the Puysegur Subduction Zone, combining them with previous observations in the region. The catalogue is constructed using a semi-automated deep-learning-based workflow for earthquake detection and association, obtaining absolute and relative earthquake locations. We also obtain over 1,000 robust focal mechanism solutions, using deep-learning approaches for P-wave first motion polarity picking. We use these solutions to construct a high-resolution representation of the spatial variability in stress along the margin by clustering mechanisms using a Quad-Tree approach and inverting for stress tensors using a Bayesian method. We combine our observations with previous observations of afterslip and tectonic tremor to infer that the interface along the Fiordland coast is weakly coupled and transitions to a more strongly coupled interface offshore to the south. In addition, we present observations that suggest the shallow part of the offshore Alpine Fault appears locked as it is under horizontal compression, while the deeper part of the fault cuts into the Australian plate along inherited fault structures.

Illuminating the Puysegur Subduction Zone using five years of seismicity

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Large parts of Aotearoa New Zealand's South Island are affected by seismic and tsunami hazard originating from the Puysegur Subduction Zone, as evidenced by large earthquakes both on- and offshore in 2025 and 2026. The Puysegur margin is also a key location to study young subduction processes, as it is transitioning to a self-sufficient system. Geophysical research along the margin is severely hindered by Fiordland's rugged nature, resulting in a limited number of well-constrained datasets.

We present a high-resolution earthquake catalogue resulting from the analysis of over five years of seismic data from the PTANGO (Puysegur Tremor and Nucleation Geophysical Observatory) network, the permanent GeoNet network and a series of temporary deployments. The catalogue was constructed using a semi-automated workflow, applying deep-learning detection, robust event association, manual evaluation, and absolute and relative hypocentre location. In addition, we use automated P-wave polarity picking, grid-search-based focal mechanism analysis and Bayesian stress inversions to decipher the Puysegur Subduction Zone's stress state in higher resolution compared to previous research. We combine all our observations together with recent data on the large M5.9 2026 Te Anau earthquake to construct a 3D geometric and tectonic model for the Puysegur Subduction Zone. Our model supports the previously proposed ``ploughshare'' model but illuminates the strong deformation of the subducted slab in new detail. We present observations of localised down-dip tearing of the Australian plate, a torn-off section of slab under Milford Sound, and provide detail on the transition between the Puysegur subduction zone and the Alpine Fault. Finally, we show that the Australian plate is under down-dip extension, suggesting prevalent slab pull. However, significant deviations from this down-dip slab pull stress state are present, reflecting the Australian plate's complex geometry.

Thermomechanical modelling of segregation and rejuvenation in TVZ-like magmas

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Silicic magma reservoirs spend most of their existence as crystal-rich mush, and the processes that reactivate them are difficult to observe directly. We present a one-dimensional thermomechanical model of a crustal magma column that resolves the vertical transport physics of these systems including hindered crystal settling, exsolved volatile ascent and Darcy percolation of melt through the packed crystal framework, all governed by conservation of heat, water, and bulk composition. Thermodynamic closure is provided by equation-of-state lookup tables computed either using Rhyolite-MELTS or the MAGEMin Gibbs energy minimiser, with the latter spanning a basalt-to-rhyolite composition axis. This ensures that phase fractions, densities, dissolved water contents, and mineral assemblages respond realistically as recharge hybridises the resident magma. Simulations of basaltic injection into a cooled mush of intermediate composition show remobilisation propagating both due to conductive heating and compositional mixing. The emergence of cumulate layers and volatile-rich lenses is also reproduced. Our goal is to quantify the conditions for mush activation in silicic systems such as those of the central Taupō Volcanic Zone. However, the same segregation physics governs the accumulation of melts and volatiles relevant to magmatic ore forming processes, and we discuss both applications.

Insights into intraplate seismicity mechanisms using surface-wave tomography and thermography of eastern North America

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Eastern North America, a stable continental region, hosts zones of significant seismic activity including the New Madrid and East Tennessee Seismic Zones (NMSZ, ETSZ). Using seismic data provided by the USArray and other recent broadband deployments, surface-wave imaging provides unprecedented amounts of information on the structure of the lithosphere and underlying mantle, offering new insights into the relationships between intraplate seismicity and continental evolution. Here, we present a new Rayleigh wave phase-velocity model for eastern North America, built using two complementary interstation measurement techniques: teleseismic cross-correlation, for short to intermediate period measurements, and waveform inversion for intermediate to long period measurements. The resulting phase-velocity model covers an 8–360 s period range, sampling the entire lithosphere-asthenosphere depth range. Our new model and recent phase-velocity models display close agreement, with our model extending to longer periods. We estimate dispersion-curve errors at a point for our model and those recently published by isolating curves' roughness, which cannot be explained by any Earth structure. Where the period range overlaps, our model's errors are similar or smaller compared to others, particularly at periods sensitive to the lithosphere-asthenosphere boundary. We then perform thermodynamic inversions of the Rayleigh-wave data together with Love wave dispersion-curves extracted from a recent global model, for estimates of lithospheric thickness and mantle temperature. We observe relatively thin lithosphere beneath the Reelfoot Rift, in the NMSZ (~150 km, compared to >200 ± 30 km either side), but not beneath other major rifts which host little seismicity. A zero-inflation model shows a statistically significant relation ($Pr < 0.05$) between lithospheric thickness, lithospheric thickness gradient and earthquake distribution. The ETSZ appears to be localised at a sharp velocity boundary, indicative of a steep lithospheric-thickness gradient. These results indicate that lithospheric thickness variations exert the primary control that localises deformation and seismicity in stable continental regions.

Mapping ancient glaciations in Central Otago

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Central Otago, New Zealand, preserves a complex geomorphological record of mid-to-late Pleistocene glaciations shaped by both climatic shifts and ongoing tectonic deformation from the Alpine Fault. This research investigates the extent and chronology of these ancient glaciations within the Clutha Valley, specifically focusing on the area between Luggate and Cromwell, to reconstruct former ice dynamics and landscape evolution.

To achieve this, the study integrates detailed geomorphological mapping with numerical glacier modelling. Mapping was conducted in ArcGIS Pro using high-resolution 0.2 m and 0.3 m aerial imagery alongside the national 8 m Digital Elevation Model. Palaeoglacier reconstruction incorporated three models, which were used to estimate ice thickness and the degree of cooling required to climatically force a glacier to its terminus.

Spatial analysis successfully identified several key glacial advances in the valley, ordered from oldest to youngest: Clyde, Lowburn, Quartz Reef, Lindis 1, Lindis 2, and Kawarau. The oldest advance, Clyde, was identified by Park (1908) and is expressed as a major outwash surface at the mouth of the Cromwell Gorge where it meets the Clyde Dam. The following glaciations of Lowburn and Quartz Reef represent major early outwash expressions preserved as high-elevation terrace sequences at Lake Dunstan. Subsequent glaciations include Lindis 1, evidenced by glacially carved bedrock and meltwater channels north of the Bendigo Reserve, and Lindis 2, characterised by extensive ground moraine extending toward the base of the Dunstan Range and Tarras.

These mapped geomorphic expressions and terrace correlations provide a refined spatial framework for understanding the region's paleoglacial history. By incorporating spatial mapping and flowline modelling, this research clarifies the localised topographic and climatic controls that governed Pleistocene ice limits in the semi-arid, tectonically active basins of Central Otago.

Emplaced or displaced? Investigating an anomalous basalt outcrop at Mount Horrible

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The Timaru Basalt forms an extensive volcanic sheet across South Canterbury, representative of the youngest period of volcanism in the South Island. The flows extend from the coast near Timaru, at their furthest extent, to Mt. Horrible, where the basalt is at its thickest and is inferred to be closest to the source. The basalt covers the summit of Mt. Horrible, overlain by a layer of loess, forming prominent cliffs along its margins. However, an unusual outcrop can be found halfway down the slopes. An anomalous intact basalt outcrop with well-preserved columnar jointing, similar to the in-situ basalt flows, occurs on the western slope of Mt. Horrible. The intact appearance of this outcrop contrasts with the scattered basalt boulders and blocks found elsewhere across the mountain.

This raises the question: how did a seemingly intact basaltic body come to be halfway down the slopes of Mt. Horrible? Did it form in place, or was it displaced after its emplacement?
This study investigates three competing hypotheses for its origin: intrusive emplacement, post-emplacement structural displacement, and post-emplacement mass-movement.

Preliminary observations favour post-emplacement mass movement, as the stratigraphic sequence below the outcrop is consistent with the upper slopes of Mt. Horrible. This suggests a downslope displacement rather than independent emplacement, however, the units dip into the slope, creating an unfavourable geometry for landslides challenging this interpretation.

To evaluate these interpretations, geological field mapping and petrographic analysis are being combined with geophysical surveys and LiDAR-derived terrain analysis. The datasets will be integrated to examine the surface and subsurface relationships among the anomalous basalt, the underlying marine sequence, the surrounding slope morphology, and the main basalt flow.

The results will provide a geological framework for determining the origin and contributing processes of the anomalous basalt and its current position.

Reconstructing the magmatic system of the 298 ka Kaingaroa eruption using phase equilibrium geobarometry

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Understanding the architecture and evolution of magmatic systems that control large caldera-forming eruptions is critical for interpreting their modern equivalents. Geobarometry provides a method of indirectly observing these processes, and we apply this to the 298 ka Kaingaroa eruption from the central Taupō Volcanic Zone. Building on previous petrological and geobarometric studies, we aim to reconstruct the architecture of the Kaingaroa magma system and interpret magma transport in the lead-up to eruption.

We collected glass major element compositions using EDS-SEM, and whole-rock major and trace element compositions using XRF for the same 40 pumice, collected throughout the stratigraphy. Preliminary results suggest that Kaingaroa is composed of 4 magma types (A-D), which are defined using whole-rock trace element compositions and principal component analysis (PCA). Using the rhyolite-MELTS geobarometer we show that magma types B and D were stored shallower than the mush at <4.1 km and between 4.8 and 5.3 km respectively, and were extracted from mush bodies between 5.7 and 10.2 km. This suggests vertical migration of magma by at least 2 km prior to eruption. Type C magma was likely stored in contact with the mush between 4.5 and 5.8 km, with extraction of melt from as deep as 8 km. Additionally, by modelling at oxygen fugacity intervals of ΔQFM 0.1, and searching for co-saturation of plagioclase + orthopyroxene + spinel ± quartz on the liquidus, we have modelled the existence of both quartz-bearing (types A and B) and quartz-absent (types C and D) mushes within the Kaingaroa magma system. These modelled mineral assemblages will be validated against the mineral assemblages of plutonic lithics collected from the Kaingaroa that we have interpreted to be mush fragments. Overall, the results suggest that the Kaingaroa magma system is complex and comprised of a heterogeneous mush, and numerous pre-eruptive storage bodies.

Hawke's Bay soil conservation modelling: a case study in avoided cost

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Hill country erosion presents ongoing environmental, social, and economic challenges in Hawke's Bay, reducing farm productivity while generating significant downstream sediment impacts. Recent extreme weather events have highlighted the scale of sediment generation from erosion-prone land and the long-term costs. Targeted soil conservation measures, particularly erosion-control tree planting, are widely recognised as an effective means of reducing landslides and sedimentation. As expectations grow for councils to demonstrate that public investment is effectively targeted and delivers measurable outcomes, robust decision-support tools are increasingly important. Systems Thinking provides a framework for evaluating complex environmental systems where uncertainty is inherent.

This study integrates spatially explicit predictive models, Scenario Planning, and System Dynamics to evaluate the long-term effectiveness of soil conservation programmes. Three future scenarios are assessed against a reference scenario of minimal intervention: (1) Best Practice, where erosion-prone land is treated to the highest standard by 2050; (2) Conventional, reflecting current management practices; and (3) Reference, where council-supported soil conservation ceases in 2027.

The Conventional scenario achieves a Benefit–Cost Ratio (BCR) of 49, compared with 25 for Best Practice. Although Best Practice delivers greater erosion reduction, reducing annual soil deposition to 2.5 Mt yr^{-1} compared with 3.3 Mt yr^{-1} under the Conventional scenario and 13 Mt yr^{-1} under the Reference scenario, its substantially higher treatment costs (NZ$260 million compared with NZ$139 million for the Conventional scenario; net present value at 4% over 2010–2050) make the additional environmental gains more difficult to justify economically. Neither intervention eliminates sedimentation entirely, as natural erosion processes and other on-farm sediment sources persist. In contrast, the Reference scenario minimises short-term expenditure but results in substantially greater long-term environmental, agricultural, and community costs.

These results demonstrate how integrating geospatial models, Scenario Planning, and System Dynamics can support transparent, evidence-based investment decisions for long-term soil conservation.

Ostler quakes network observes seismicity for inferring deep fault structure relative to active mapped faults

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The Ostler Fault is a prominent reverse fault along the margin of the Southern Alps and Central Canterbury tectonic domains, near the junction with the Otago range and basin domain. It is one of the most active faults in the region east of the central Alpine Fault, and underlies major New Zealand hydroelectric infrastructure. In recent studies related to the New Zealand National Seismic Hazard Model 2022, it shows ~2 mm/yr geologic slip rate and ~2 mm/yr geodetic slip deficit rate. The long-term seismicity from the permanent network shows a broad relatively dense patch of seismicity across the Ostler Fault region. With only one permanent station (LBZ) in the region, the earthquake depths are poorly constrained. The currently installed Ostler quakes network, running November 2025 through March 2027, has 12 temporary seismographs to obtain accurate locations for very small magnitude earthquakes that are not observed by the sparse permanent network. This will give reliable seismogenic depths for hazard models, and will enhance understanding of the deep Ostler Fault structures and identify seismic activity on adjacent potentially active fault structures.

Most initially observed seismicity occurs in the vicinity of the west-dipping Ostler Fault. Southern seismicity informs the broad zone of diverse faulting that includes several reverse faults and the sinistral Fern Gully Fault. Sparse eastern seismicity occurs in the region of southeast-dipping reverse faults, including Irishman Creek. We apply a machine-learning workflow which combines a phase picker and a search to detect earthquakes, to 8 months of data. The resulting hypocentre locations provide preliminary seismotectonic interpretation for the Ostler Fault area.

How long does it take to construct an andesitic cone? New insights into eruption chronology and magma evolution from the Mangatawai Tephra record

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The timescales and periodicities of long-lived andesitic eruptive episodes remain poorly constrained, despite their importance for volcanic hazard management and risk assessment. Tongariro Volcanic Centre has been persistently active throughout the Holocene, producing numerous large explosive eruptions from multiple and widely spaced vents before eruptive activity became increasingly focused at Ngāuruhoe by ~3.5 ka, marking a shift towards smaller, more frequent eruptions. The Mangatawai Tephra is a key regional marker bed that records this transition, preserving a well-stratified sequence of frequent explosive eruptions associated with the Ngāuruhoe's main cone-building phase. Its detailed stratigraphy, and abundant, well-preserved beech leaves suitable for radiocarbon dating provide an opportunity to constrain the nature and timing of renewed cone-building activity at TgVC. Here, we combine high-resolution field stratigraphy with new radiocarbon ages, geochemical and petrological analyses to establish a refined framework for the Mangatawai Tephra.

We divide the sequence into three primary eruptive packages, based on field relationships along north-south and east-west transects, combined with glass chemistry and mineralogy. Each package records a distinct phase of activity separated by time breaks and soil formation. Package 1 comprises the oldest eruptive units and is characterised by four main subunits separated by well-developed paleosols, indicating discrete episodes of activity. Package 2 records a transition to sustained eruptive activity, preserving a near-continuous sequence of tephra, with little to no soil development between eruptions. Package 3 comprises the youngest subunits, recording a return to more intermittent, lower-frequency eruptions. Stratigraphically constrained glass analyses reveal systematic temporal variations in major element compositions within and between the packages, particularly in Fe, Ti, and Mg, indicating evolving magmatic conditions and ongoing magma recharge throughout the sequence. Together, these results refine the stratigraphy and chronology of the Mangatawai Tephra, providing new constraints on the duration, periodicity, and magmatic evolution of Ngāuruhoe.

Facies architecture of the Taupō Ignimbrite: deciphering spatial variations in sedimentary characteristics

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The 232 CE Taupō eruption was the most powerful eruption on Earth in the last 5,000 years, culminating in a large pyroclastic density current that inundated an area of ~20,000 km². The physical properties of the ignimbrite and its distinct lithofacies indicate deposition via a concentrated flow whilst its large areal extent and runout (80 ± 10 km) suggest deposition via a dilute flow. The most voluminous facies, layer 2, was classified as ignimbrite veneer deposit (IVD) or valley-ponded ignimbrite (VPI) based on the nature of the paleo-landscape where it was deposited.

To understand the dynamics and evolution of the flow, spatial variations in sedimentological and morphological characteristics of the Taupō ignimbrite east to northeast from source were mapped and analysed, primarily in the Kaingaroa and Taupō Forest. This analysis shows that layer 2 displayed repeatable facies structures across its entire runout length. Localised variations were re-interpreted resulting in the IVD being classified into five sub-facies, each exhibiting distinct characteristics that are further corroborated by sedimentological laboratory analysis. The IVD shows great variety in thickness, componentry and grain size distribution between the low-relief Kaingaroa Forest and the high-relief Taupō Forest with these factors corresponding to the newly defined sub-facies within the IVD. The re-interpretation also recognised two sub-facies of the VPI.

A new facies architecture is presented for the Taupō ignimbrite based on this detailed spatial and sedimentological analysis. The sedimentary characteristics of the ignimbrite indicate varying influence of internal and external controls on flow behaviour and evolution. Proximally, physical characteristics such as a lack of grading and poorer sorting indicate deposition from a dilute flow. In contrast, at distance from source, the flow became more condensed and strongly influenced by interaction with the paleo-landscape which is depicted by the greater variety in veneer morphology.

3D volcano terrain models

James Ford

Science tends to be conveyed effectively and understood intuitively when presented visually or in a practical hands-on manner. Advances in technology allow us to create high fidelity digital 3D models of landscapes that can be explored interactively, rendered as still images, and 3D printed to create physical terrain models. This talk will cover a set of examples where this has been implemented for local volcanic landscapes and the concepts behind the implementations.

Environmental magnetism as a redox proxy, Patea/Doubtful Sound, Fiordland, New Zealand: implications for carbon sequestration

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Deep fjord basins in Fiordland accumulate and preserve substantial volumes of organic-rich sediment, making them important carbon sinks within Aotearoa New Zealand's coastal system. Environmental magnetic proxies provide an efficient, non-destructive way to track changes in magnetic mineralogy, concentration, and grain-size, offering insight into how redox conditions and surrounding environmental processes evolved through time.

Here we present highly resolved down-core environmental magnetic records from a ~8.4 m sediment core (SO309-GeoB-26347-1) collected in Patea/Doubtful Sound, Fiordland, New Zealand. A basal radiocarbon age indicates the core spans the last ~5000 years.

Alternating Field demagnetisation indicates that magnetite (Fe_3O_4) is the dominant magnetic mineral down-core; however, at least seven distinct intervals of gyroremanent magnetisation indicate greigite (Fe_3S_4), the sulfur analog of magnetite, which forms under euxinic (anoxic and sulfidic) conditions favourable to carbon sequestration. Paleomagnetic inclination varies around the expected Geocentric Axial Dipole inclination in the top 6.5 metres of the core, suggesting largely syndepositional greigite deposition/formation and rapid water chemistry transitions.

These results will be placed in the broader context of Holocene environmental change to assess the likely drivers of anoxic water-column and sedimentary conditions within this large fjord sub-basin.

Magma-fluid-host rock interactions in the Ferrar Large Igneous Province, Antarctica

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The emplacement of Large Igneous Provinces (LIPs) represent some of Earth's most significant magmatic events, driving crustal heating, volatile release and hydrothermal circulation. However, due to the absence of active LIP systems and rare plumbing system outcrop exposures, the extent and controls of hydrothermal alteration associated with mafic LIP emplacement remain poorly understood. The Jurassic Ferrar LIP in the McMurdo Dry Valleys, Antarctica, features exceptional exposures of an igneous sill complex, providing a rare opportunity to investigate plumbing system architecture, fluid pathways, and alteration at the outcrop scale. This study aims to characterise the spatial distribution and controls of hydrothermal alteration in this LIP, and assess how intrusion emplacement influenced fluid flow and associated elemental redistribution.

Petrographic analysis of doleritic intrusions and sedimentary host rock has identified several secondary alteration minerals, including chlorite, calcite, epidote, sulfides and other clays, indicating evolving hydrothermal conditions. Electron microprobe analyses reveal that chlorite is generally Fe-rich and Al-poor, especially in the shallow plumbing system (<1 km depth). Empirical and semi-empirical chlorite geothermometry suggests at least three discrete geothermal systems operating in the McMurdo Dry Valleys during LIP emplacement. Ongoing work will further characterize alteration minerology/clays, mass transfer, changes in effective porosity and fluid composition. Together, these analyses will provide new insights into the spatial distribution, intensity, and evolution of hydrothermal alteration within the Ferrar magmatic plumbing system. This work advances understanding of fluid circulation and volatile transport within mafic intrusion systems, offering a valuable framework for interpreting ancient LIPs and determining alteration patterns and fluid/volatile movement in partially exposed settings.

DARE, a new national collaboratory to deliver multi-hazard resilience in Aotearoa New Zealand

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The last decade has ushered in rapidly increasing risk from natural hazards as the effects of climate change accelerate and compound Aotearoa New Zealand's existing risk trajectory. Fortunately, advancing global capability in applications of high-performance computing and artificial intelligence provide us with a crucial opportunity to understand and address increasing and compounding risks due to climate change and natural hazards. A widely interdisciplinary digital ecosystem within the Natural Hazards Resilience Platform (NHRP) has been designed to apply modern technological advances to generate scientific advice to drive Aotearoa resilience to natural hazards through sustainable growth, mitigation and adaptation.

We have begun implementing the Digital Aotearoa Resilience Engine (DARE). DARE is a harmonised digital ecosystem that will leverage existing research, assimilate emerging knowledge and data, and create an inclusive national collaboratory for resilience science. Based on key concepts of modern HPC and A.I., DARE will apply the most powerful and novel research methods to support better resilience decisions. DARE is mission-led, with the analytical core based on resilience questions posed by the wider NHRP and extensive engagement with stakeholders. In this talk, we will introduce the DARE infrastructure and make an open call to action for broad interdisciplinary and cross-sector participation to create enduring resilience for Aotearoa New Zealand in the presence of the dire challenges of future cascading and compounding natural hazards.

Settlement performance of Rotorua Lake Sediments

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The Rotorua urban area occupies the southern portion of the Rotorua Caldera, a topographic basin infilled with interlayered volcaniclastic, alluvial and lake sediments. Ongoing urban expansion increasingly requires development of sites underlain by soft and potentially compressible lake sediments. Settlement predictions for these materials are commonly derived from cone penetration test (CPT) correlations, which often predict significant settlements that need ground improvement mitigation in order to reduce predicted settlements to within tolerable limits. However, often observed field performance differs significantly to those CPT correlated settlements.

Monitoring data from trial embankments constructed over Rotorua Lake Sediments indicate substantially lower settlements than predicted using conventional CPT-based methods. At the primary study site, two trial embankments, 0.9 m and 1.7 m high respectively, were constructed and instrumented for settlement monitoring over a three-month period. Applied surcharge loads ranged from 13.5 to 27 kPa. Measured settlements were in the order of 8-15 mm whereas CPT-based correlations estimated settlements of up to 125 mm. The majority of the settlement was interpreted to occur within a firm silt alluvial and lacustrine silt between approximately 3 m and 10 m below ground level. As a result of the substantially less observed settlements from the trial embankments, ground improvement was not considered necessary for the proposed development.

These findings indicate that settlement predictions for Rotorua Lake sediments based solely on standard CPT correlations may be over conservative and highlight the value of site-specific trial embankment testing. Further investigation is recommended to better quantify the relationship between in situ testing and observed settlement behaviour in the Rotorua Basin.

Weathering-induced slope failure at the Makorori Landslide, Gisborne

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Landslides in the Gisborne region pose ongoing risks to communities and infrastructure, yet the material controls on slope failure in this geological setting remain poorly understood. This research investigates how weathering and the resulting material properties of the interbedded mudstones and sandstones of the Tunanui Formation (Mlu), Tolaga Group, Middle Miocene, contribute to slope instability at the Makorori landslide, improving understanding of hazard in similar geological settings across the region.

Field-based crack mapping characterised the extent and morphology of the failure surface, while laboratory analyses—including triaxial testing, particle size analysis, clay mineral analysis, and Atterberg limit testing—assessed the mineralogical and geotechnical properties of the material. These data are being integrated into a 3D model of the landslide to visualise failure geometry and material distribution across the site.

Chemical weathering is identified as the primary driver of failure, with rock layers progressively breaking down into clay-rich material. Early XRD analysis identifies montmorillonite, a shrink-swell clay, as the dominant clay phase within the failure zone. This expansive clay governs failure style and rate of movement, producing slow slides in the upper areas of the site, while joints and faults throughout the material cause peeling of individual beds, driving toppling and falls near the base and margins of the site. The landslide remains active, with frequent smaller failures and a significant recent reactivation on the southern end of the site during Cyclone Gabrielle.

Given the limited existing research on landslide mechanics in this specific geological setting, and the presence of comparable interbedded mudstone-sandstone sequences at other sites with nearby communities, this work addresses an important knowledge gap. Findings will support the local council in future hazard management and risk mitigation in the Gisborne region.

Natural hydrogen systems in Aotearoa New Zealand – a potential sovereign, low-cost, low-carbon energy future?

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Natural hydrogen is an emerging option for sovereign-sourced, low-cost, low-carbon energy. Convergent plate boundaries offer a range of tectonic settings where ultramafic rock interacts with water at potentially exploitable subsurface depths. Two phases of convergent subduction highlight these modes of coupled serpentinization and hydrogen generation within Aotearoa New Zealand (A-NZ). The first comprises two belts of obducted Permian ultramafics and ophiolites, that are exposed and variably buried across the South and North islands, respectively. Dehydrating slab subduction along the Hikurangi margin is the second mode where methane hydrates, seeps and plumes, mud volcanism, hyper-saline seeps, and hot springs (and localized hydrogen emissions) evince extensive fluid-flow. Thirdly, serpentinization is common where crustal scale faults (including the Alpine Fault) intersect peridotites, forming conduits for meteoric water. Similarly, the Taranaki thrust fault juxtaposes the ultramafic basement beneath >10 km thick sediment sequences. A-NZ is an archetypal convergent margin where tectonic assembly, obducted ophiolites, spatiotemporal variability of serpentinization, fault-controlled permeability, and basin evolution are first-order requirements for natural hydrogen systems. Serpentinization processes commonly limit the evolution and preservation of proximal sediment basins for hydrogen accumulation, though the Taranaki region may represent an example where both processes are spatially and temporally aligned.

Late Holocene carbon burial in Fiordland marine basins

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Globally, fjords are recognised as locations with high rates of organic carbon (OC) burial at the land-ocean interface. Spatial and temporal variations in climate, environment and sedimentary processes both between and within fjords complicates the reconstruction of sediment accumulation rates, which are key to determining OC burial. In Fiordland, steep catchments and heavy rainfall drives continuous lateral transport of large quantities of terrestrially derived sediment into the fjords. On-going sediment deposition is interspersed with geologically instantaneous deposits from tectonic and climate-driven landslides (event layers). The complex and dynamic sedimentary environment in Fiordland makes quantifying sediment accumulation and OC burial challenging.

To constrain sediment accumulation rates in the region, we developed age-depth models for fjord basins that are representative of the diverse marine sedimentary environments in Fiordland. Our multifaceted approach utilised a combination of sediment core lengths and types, and integrated chronological techniques (^{210}Pb and radiocarbon), core analysis outputs (i.e. CT scans, images, non-destructive core scanning), and Bayesian modelling. Key to this approach was consistent application of the suite of techniques across the target basins to ensure comparable outputs. Bayesian age-depth modelling allows event layers to be incorporated, which significantly impact sediment accumulation estimates and OC burial. Our revised age models indicate higher sediment accumulation than reported in previous studies.

We reconstructed OC burial in Fiordland during the late Holocene using downcore carbon concentrations from the target basins and our updated sediment accumulation rates. On-going accumulation provides 'background' values of OC burial, whilst events provide instantaneous deposition of sediment (sometimes OC-rich) to individual basins but have limited lateral extent. Based on our new data, we provide updated values for OC burial in Fiordland marine sediments, and discuss how climate, tectonic events, and anthropogenic change have influenced, and may continue to influence, OC burial in Fiordland.

Exploring the long-term fate of organic carbon exported from Aotearoa New Zealand fjords

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Despite the significance of fjords to global carbon sequestration, the ultimate fate of terrestrial organic carbon (OC) in these systems is poorly constrained. Rapid sedimentation rates and subsequent high OC transport and burial rates are accentuated due to heavy rainfall, weather events, earthquake- and climate-driven landslides, gullying, and mass wasting processes. The age, composition, and fate of the transported and sequestered OC source matrix impact global carbon budgets through time.

Previous examinations have looked at modern OC sources, transport, transformation, and sequestration within the Aotearoa New Zealand fjords. Here, we have extended this OC characterisation from within the fjords to offshore sediments to identify the fate of OC exported to the ocean and examine the potential for long-term sequestration or remineralisation of buried carbon both within and outside the fjordic environment. We have used ramped pyrolysis oxidation (RPO) radiocarbon measurements, combined with pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS), to disentangle, apportion, and characterise OC provenance in coastal sediments, tracking carbon from its terrestrial and marine sources through physical transport within the fjords to ocean export and burial offshore. Through correlating molecular OC fingerprints in sediments within the fjords with offshore sediments, we are able to discern the transport, transformation, and burial processes within the Fiordland terrestrial carbon cycle through time.

Are the driving forces of plate tectonics mechanically complete?

An engineering perspective

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The theory of plate tectonics successfully explains the observed motions of the Earth's lithosphere and has become one of the most successful theories in Earth science. However, despite broad agreement on the kinematics of plate motion, significant uncertainty remains regarding the relative importance of the proposed driving mechanisms, including ridge push, slab pull, mantle convection, and westward lithospheric drift. This presentation examines these mechanisms from a mechanical engineering perspective using a common set of first-principles questions: Does the proposed force demonstrably exist? Is its direction physically well defined? Does it act on a sufficient mass to influence an entire tectonic plate? Can it produce the observed motion? The presentation argues that many published models rely on simplifying assumptions that are necessary for numerical modelling but can make it difficult to distinguish between explanatory models and independently validated physical mechanisms. Particular attention is given to the distinction between boundary forces and body forces, the problem of subduction initiation, the geometry of ridge systems, and the influence of inertial forces arising from the Earth's various accelerations. Rather than proposing that existing tectonic theory be discarded, this work asks whether the current inventory of driving forces is mechanically complete. It is suggested that inertial body forces generated by Earth's rotation, oscillation, wobble, changing spin, Earth-Moon barycentric motion, and orbital motion deserve systematic quantitative evaluation alongside the traditionally recognised driving mechanisms. The objective is not to replace plate tectonic theory but to broaden the discussion of the forces responsible for plate motion using a unified mechanical framework based on Newtonian dynamics.

Transforming field culture in the Geosciences: insights from an AGU survey and a new training program

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Field-based research is central to geoscience training and research, yet field environments can heighten risks for interpersonal harm because of strong power differentials, blurred professional-social boundaries, close living conditions, and physical demands. These dynamics can undermine safety, belonging, team functioning, and retention, particularly for scientists from historically excluded groups.

To better understand these challenges, we surveyed members of the American Geophysical Union (n = 289) about the prevalence, perceived impact, and reporting of harmful field interactions (HFIs), defined as 26 behaviours spanning incivility, microaggressions, and harassment. Eighty percent of respondents reported experiencing or witnessing at least one HFI. The most frequently reported categories were Aggression and Hostility, Undermining of Work, and Inappropriate Sexual Behaviour. Respondents identified Undermining of Work, Aggression and Hostility, and Social Harassment among the most negatively impactful experiences. Perpetrators were typically hierarchically above the affected individual, and 75% of HFIs were not reported, commonly because incidents were perceived as “not serious enough,” respondents feared professional or social consequences, reporting pathways were unclear, or confidence in follow-up was low.

These findings informed the development of ADVANCEing FieldSafety, a free online training suite designed to prepare field teams for safer, more inclusive, and productive field experiences. The program integrates a Massive Open Online Course (MOOC) hosted on Coursera, a field-ready resource hub, and structured reflection workshops. Grounded in an intersectional framework, the training addresses harassment, power dynamics, professional conduct, field safety, and team culture.

This presentation presents the findings of the research study, connects community-identified concerns with the ADVANCEing FieldSafety course, presents evaluation results and lessons from early implementation, and offers recommendations for field leaders, institutions, and funders seeking to strengthen safety, equity, and participation in geoscience fieldwork.

Crustal stress heterogeneity at volcanic centres in the Taupō Rift revealed through stress inversion of focal mechanisms: are volcanic centres a cause or a symptom?

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Although the structure, segmentation, and kinematics of the Taupō Rift have been extensively investigated using both geological and geophysical data, the influence of the Taupō and Ōkataina volcanic centres on the evolution of the rift remains poorly constrained. Using the open-source Python package pySATSI, we analysed a catalogue of ~1300 earthquake focal mechanisms recorded between 2004 and 2026. With this catalogue, we produced a rift-wide stress inversion and developed a revised interpretation of rift segmentation and associated volcano-tectonic interactions. Our results demonstrate a consistent trench-perpendicular extension direction and a rift-wide maximum horizontal stress (SHmax) orientation of 052° ± 26° (1σ), with a median absolute deviation of 15°, indicating a dominant NE-SW trend (as would be expected) with substantial along-strike variability. Despite the diversity of focal mechanisms in the catalogue, stress inversion results indicate a stress state primarily consistent with a normal-faulting regime. However, strike-slip solutions explain ~32% of stress inversions in non-volcanic sections of the rift, whereas only 3% of stress inversions in volcanic regions yield a non-normal stress solution. Counterclockwise rotations in the SHmax orientation towards ~010-020° occur at active caldera complexes, which are bracketed by rift segments with SHmax solutions aligned to ~050°. These localised SHmax perturbations are consistent with the presence of step-overs or accommodation zones that link offset, segmented rift basins. Furthermore, these accommodation zones are spatially coincident with the Taupō and Ōkataina volcanic centres, which host extensive crustal-scale magma mush systems that have produced numerous, large silicic eruptions, three of which were accompanied by caldera collapse, during the last 60 kyr. We consider whether the co-location of these features suggests that rift structure and segmentation control the location of volcanic centres, or whether the location of volcanic centres determines the position of such accommodation zones.

Caldera-adjacent rift segments accommodate syn-eruptive fault rupture during the larger eruptions from Taupō volcano

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The two currently active caldera volcanoes in the central Taupō Volcanic Zone, Taupō and Ōkataina, are bracketed by arrays of normal faults associated with the Taupō Rift. Evidence from Ōkataina volcano, documented in paleoseismic trenches, has demonstrated that a significant proportion of ruptures on caldera-adjacent faults occurred in association with volcanic eruptions. Although hypothesised to have occurred during the ~25.5 ka Ōruanui supereruption, geological evidence of syn-eruptive fault rupture at Taupō volcano is sparse. Intra-rift fault activity has been demonstrated to have occurred contemporaneously with the 232 CE ± 10 caldera-forming eruption, however, the pre-232 CE rupture history of the Kaiapo fault remains poorly constrained. Therefore, we excavated four trenches across strands of the Kaiapo Fault to assess whether syn-eruptive fault activity is typical of this structure and to investigate whether there is a relationship between eruption volumes and the prevalence of syn-eruptive fault activity at Taupō volcano. Data from these trenches indicate that at least 14 fault ruptures have occurred since the emplacement of Unit B (~12 ka) from Taupō. Six of these fault ruptures occurred in the lead-up to, during, or after eruptions from the volcano. The eruptions associated with these ruptures are those that deposited units E (~10 ka, 2 km^3 DRE), S (~3.5 ka, 7.5 km^3 DRE), V (~2.8 ka, 0.4 km3 DRE) and Y (232 CE ± 10, 35 km^3 DRE), four of the six largest eruptions in the last ~12,000 ka. Our results, therefore, suggest that eruptions ≥ 0.4 km^3 DRE are likely to involve syn-eruptive fault rupture in rift segments adjacent to Taupō volcano.

Grain by grain: a history of ice rafting debris from northwest Greenland during the Cenozoic

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The Greenland Ice Sheet provides one of the fastest responses of the Earth system to anthropogenic warming, yet the timing and environmental conditions of its initial inception remain poorly constrained. While the Cenozoic progression of the Antarctic Ice Sheet is broadly understood, equivalent deep-sea proxy records for the Arctic are unable to distinguish between Northern Hemisphere ice sources. This limits understanding of the environmental conditions that support permanent ice presence in Greenland. IODP Expedition 400 recovered 975 m of sediment core at Site U1607, on the northwestern Greenland continental shelf, capturing marine-terminating ice dynamics through ice-rafted debris (IRD) deposition.

Site U1607 consists of alternating sands and muds deposited in a shallow marine environment. The section exhibits numerous coarse-grained intervals (>250 µm) composed of lithogenic material (sand deposited in environmental equilibrium and IRD), authigenic minerals (glauconite, glendonite, fe-oxides and pyrite), and biogenic components (macro and micro calcareous fossil). As such, standard quantitative IRD methodologies (total weight percent >250 µm material) are compromised at this site. Therefore, we employed a qualitative visual assessment of the sieved +250 µm fraction under a binocular microscope to isolate characteristic IRD features, such as angular crystals and polished grains with dish shaped impact structures. This is a conservative approach providing a baseline for identifying IRD events and validating more automated methods of identifying IRD from the samples.

IRD occurrences are sparse in the lowermost sections but increase in frequency and volume up core making up to 60% of >250um, indicating a transition from sporadic Oligocene ice rafting to regular paced events in the Late Miocene, based on recent developments in the shipboard age model. These findings offer new insights into the stability of the Greenland Ice Sheet during warmer-than-present climate states.

Towards well-informed landforms – development of a standardised classification of terms and definitions for geomorphological mapping in Aotearoa New Zealand.

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Alongside the well-known QMAP geological map series and GIS datasets, Earth Sciences NZ and predecessor organisations have been mapping geomorphological features in various parts of Aotearoa New Zealand. Geomorphology provides important information for interpreting Quaternary-age near-surface geological deposits, recognition of potentially hazardous features such as landslides and active faults, and defining areas of human landscape modification including landforms that may have significant cultural value (e.g. pā sites).

Aotearoa New Zealand's most extensive geomorphological map, at 1:100,000-scale, covers a ~30,000 km^2 coast-to-coast sector of the central South Island (Barrell et al. 2011 – GNS Monograph 27) and emphasises glacial landforms. It initiated a geomorphological data structure that was further developed in an urban-focused detailed geomorphological map of eastern Canterbury (Begg et al. 2015 – GNS Geological Map 3), with ongoing development arising from recently published and in progress geomorphological maps for Pukekohe (Townsend et al. 2026 – GNS Geological Map 12), Napier-Hastings, Kumeu-Silverdale, Aoraki-Mt Cook National Park, and a geological map of the Auckland Volcanic Field.

An important issue that has arisen while compiling these maps is the lack of a comprehensive geomorphological framework for classifying the various landform features of Aotearoa New Zealand. We are addressing this by developing a data dictionary to provide consistent terminology and descriptions of geomorphological features, following international best practise. Within GIS software, the mapper can classify these features via a controlled list of attributes.

The Earth Sciences NZ geomorphological feature definition framework will encompass the suite of geomorphological features associated with a range of different environments that exist in Aotearoa New Zealand. The proposed documentation of this standardised data dictionary in a publicly-available report, with illustrative examples of many of these landforms, will aid consistency and clarity of geomorphological mapping, both for mappers and users of the data.

Framboidal pyrite reactivity in Pohokura Caprock: an experimental batch-reaction study of hydrogen-brine-rock interactions

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The disconnection between the intermittent and variable seasonal efficiency of renewable energy sources and our consistently growing energy demand has proved to be a silent bottleneck in the balance of societal growth and our responsibility to future generations. Underground hydrogen storage has been proposed as a potential solution, enabling excess renewable electricity to be converted into hydrogen and stored in subsurface geological formations. However, the success of storage relies in part on the geochemical compatibility of hydrogen with reservoir and caprock materials. Preliminary research using synthetic mineral systems alone cannot be directly transferred to complex site-specific geological formations, where heterogeneous mineral assemblages, brine chemistry, organic matter, and competing redox reactions may substantially alter reaction pathways, rates, and magnitudes. Site-specific investigation is therefore required to determine how hydrogen interacts within the Pohokura gas field, a prospective UHS site in New Zealand's Taranaki Basin, and whether these reactions could affect storage performance.

Within this context, this study considers whether the identification of framboidal pyrite, a known primary reactive mineral in the Pohokura field, impacts the feasibility of wide-scale UHS in New Zealand? To address this question, hydrogen-brine-caprock interactions were investigated using 165 batch-reaction experiments. Six caprock samples collected from approximately 3-5 km depth are examined under controlled variations in hydrogen exposure, particle size, brine saturation, ageing, and reaction conditions to distinguish hydrogen-driven alteration from natural lithological variability and baseline brine-rock equilibration. A suite of geochemical analytical techniques is used to assess micro and bulk-scale changes in hydrogen consumption, sulfide transformation, carbonate buffering, and mineral dissolution or precipitation. From this, a site-specific understanding can be gained of the abundance of accessible, kinetically reactive sulfur present, the extent of hydrogen-driven alteration, and which minerals, morphologies, and fluids buffer, inhibit, or redirect the resulting reactions.

Densifying offshore tsunami observation networks via deep learning waveform interpolation for improved wavefield data assimilation

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Dense and well-distributed offshore observations may underpin accurate real-time prediction of tsunami wavefields, even without prior knowledge of the source. The existing global network of Deep-ocean Assessment and Reporting of Tsunamis (DART) buoys provides reliable open-ocean measurements at strategic places around subduction zones. Emerging technology based on optical fibre sensing on transoceanic submarine telecommunications cables through laser interferometry methods offers the potential for continuous seafloor observations at along existing cables. However, even when combined, the DART and submarine cable networks leave significant spatial gaps that degrade the reliability of tsunami data assimilation (DA) schemes. This study proposes a framework for virtual network densification using machine learning (ML) to predict tsunami waveforms at unobserved locations, thereby expanding effective sensor coverage. We focus on the southwest Pacific region, where a submarine cable connecting Auckland and Sydney represents a candidate sensing infrastructure. We evaluate our tsunami prediction in New Zealand using a hypothetical Mw 7.9 earthquake scenario on the Vanuatu subduction zone, assuming that the tsunami is observed at both DART buoy stations and along the fibre optic cable. We first assess the performance of a previously established linear interpolation approach to predict the tsunami at virtual stations between the real observation stations. We then train and evaluate several ML architectures including U-Net, a type of deep learning architecture adapted here to work on 1D tsunami time series at the virtual stations. The ML-predicted virtual observations are subsequently incorporated into a tsunami DA to reconstruct the full wavefields. Experiments demonstrate that the densified virtual network substantially improves wavefield prediction accuracy relative to the sparse original network, particularly for coastal areas poorly constrained by sensor coverage. Furthermore, the approach is source agnostic and provides a pathway to forecasting tsunami generated by all possible sources, not just earthquakes.

The role of subduction zone structure in controlling megathrust slip: insights from the 1952 and 2025 Kamchatka earthquakes and tsunamis

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The 29 July 2025 earthquake (Mw 8.7) offshore Kamchatka provides a unique opportunity to reassess the source of the 1952 Kamchatka megathrust earthquake (Mw 8.9). Both earthquakes ruptured the same plate interface and generated Pacific-wide tsunamis, yet their occurrence only 73 years apart which is a short time span. The availability of high-quality offshore DART tsunami observations of the 2025 event provides constraints on the earthquake source. We first use tsunami waveforms from DART stations to estimate the slip distribution of the 2025 earthquake. The resulting model has a major slip region extending approximately 500 km along strike at a depth of ~30 km, and reaching a maximum slip of ~12 m. Time-shift and amplitude-scaling coefficients are then derived by fitting observed coastal tsunami waveforms to simulations based on this reference model. With an additional correction for clock errors in the historical records, these parameters are used to invert the tsunami observations of the 1952 earthquake. The resulting model has a rupture extending approximately 700 km and maximum slip of ~18 m, also concentrated near a depth of ~30 km. Both models show relatively limited slip in the shallowest portion of the megathrust near the trench. We evaluate geological controls on these slip distributions by integrating reprocessed residual bathymetric and gravity anomalies, with onshore geology and gravity modelling. This analysis suggests the along-strike extents of both earthquakes were limited by a subducting fracture zone and an inherited tectonic suture in the overthrusting plate, respectively. It shows large co-seismic displacements in both events was concentrated predominantly down-dip of a ~70 km wide, low-density outer-forearc wedge. The width of this wedge may have played a key role in limiting the size of tsunami generated by these earthquakes. The results provide new constraints on the relationship between subducting zone structure and megathrust rupture.

Displacement rates and earthquake prehistory of the Ostler Fault, Mackenzie Basin, Aotearoa

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The Ostler Fault is an active reverse fault along the foothills of the Southern alps within the Mackenzie Basin displacing Late Pleistocene glacial deposits, outwash surfaces, and river terraces dated between 15.5 and 271 ka. The fault is adjacent to key tourist and power infrastructure in Lake Pukaki, Twizel and Ōhau, mean that understanding its behaviour and earthquake history is critical to accurate seismic risk assessment. Spatial and temporal variations of displacements constrain the displacement and earthquake history of the Ostler Fault. Fault traces have been mapped and displacements measured using a regional 1 m LiDAR DEM. Based on this remapping, the Ostler Fault has been sub-divided into six distinct geometric sections: the Southern, South Central, North Central, Haybarn, Ben Ōhau, and Northern sections. The ages of displaced surfaces have been estimated using existing Optically Stimulated Luminescence dates and correlation of displaced surfaces to established moraine ages within the Pukaki, Ōhau, and Ahuriri catchments. Fault displacement rates are calculated at 16 locations along the fault which were used to construct a displacement-rate profile. These rates are summed with vertical separation rates from folding to estimate 'Total vertical displacement rate', which is inferred to represent the fault displacement rate at depth. Folding is restricted to the hanging wall of the Ostler Fault on the South Central and North Central sections in the centre of the basin. Folding accommodates 0.1 to 0.7 mm/yr of vertical separation representing 40% of offset in places. Preliminary results have found a maximum fault slip of 〖1.50〗_(-0.12)^(+0.30) mm/yr. At individual sites long-term displacement rates (> 30 kyr) are approximately linear, while short-term (< 30 kyr) displacement rates appear to vary. These variations are consistent with temporal changes in the recurrence intervals and slip per event for individual earthquakes.

Northern Waiotapu: delineate geothermal upflow from active and preserved geothermal features

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The Waiotapu geothermal field (17 km^2) has the largest area of surface hydrothermal alteration of the 20 active high enthalpy geothermal systems in the Taupo Volcanic Zone, New Zealand, with the greatest variety of active and preserved types of surface manifestations. The Northern Waiotapu locality hosts a preserved (inactive) siliceous sinter sheet of up to 3 m thickness and 150 m^2 areal extent, formed by near neutral alkali pH fluids that is currently being overprinted by 20 recently observed hot springs, with temperatures ranging from 38.4 °C to 99.3°C and pH ranging from 2.56 to 8.77. This is the only known high-temperature neutral pH springs in the Waiotapu geothermal field. Herein, we examine the textures and trace elemental concentrations of the preserved and actively forming sinter deposits, the age of the fossil sinter sheet in relation to formation of Champagne Pool, and the fluid chemistry and biology of the, Northern Waiotapu hot springs to elucidate the spatial and temporal association of this intermittently active and relatively long-lived alkali chloride thermal discharge area. This examination shows that the Northern Waiotapu site represents the primary location of upflow and mineralised, boiled near neutral alkali fluids within the geothermal field for more than 1000 years and that detailed textural and chemical examination can be utilise to delineate primary geothermal upflow and understanding mineralisation processes within the active and preserved geothermal system.

Newly discovered pumice fall deposits on Tenerife, Canary Islands, reveal continuous felsic activity >540 – 169 Ka

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Las Cañadas caldera (LCC), Tenerife, is an active volcanic system that has produced multiple large-scale explosive Plinian and caldera-forming eruptions between 1.84–0.169 Ma. These eruptions are interpreted to be grouped into three formations and interrupted by hiatuses in phonolitic activity of ~200 Kyr. The deposits of major explosive eruptions from LCC are well documented, yet the deposits of many smaller-sized explosive eruptions are undescribed. This, coupled with offshore marine core observations of continuous explosive activity of LCC during hiatuses, means our current knowledge into the magnitude, frequency, and hazards of explosive volcanic activity at LCC are incomplete.

Here, we more than triple the number of recognised (characterised) explosive eruptions sourced during the third eruptive cycle (Diego Hernández Formation (DHF)) from 12 to 50, and extend the beginning of the DHF from >370 Ka to >540 Ka. We document 32 previously undescribed deposits and revise a further 8. Of these, 21 are in the caldera (17 pumice falls and 4 ignimbrites), erupted between >540–319 Ka, and 19 medial to distal deposits on the caldera flanks erupted towards the end of the DHF (<273 Ka). Only 2 DHF deposits older than 319 Ka are recognised in literature, so these proximal deposits provide direct evidence for continuous phonolitic explosive activity during the hypothesised 200 Kyr hiatus between the 2nd and 3rd cycles. Paucity in dating of DHF deposits, variable erosion and petrogenesis on the island, and homogenous characteristics of deposits, leave uncertainties in correlating deposits younger than 273 Ka.

Nevertheless, field fingerprinting techniques coupled with granulometric and component analyses, allow interpretation of eruptive styles and evolution of LCC over ~400 Kyr, providing a more robust terrestrial tephro-stratigraphic record and future eruption forecasting estimates. This study suggests continuous activity between eruption cycles, and updates to previous stratigraphic models.

Towards a modern deformation model for New Zealand: insights from nine years of InSAR observations.

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NZGD2000, New Zealand's coordinate system, relies on a deformation model to account for the ongoing movement of the landmass relative to its fixed 01/01/2000 reference position. Where this movement is abrupt rather than gradual, most notably following major earthquakes, the model applies patches to correct for localised co-seismic and post-seismic deformation. This approach was applied extensively in Christchurch, and later Kaikoura.

The 2016 Kaikoura earthquake prompted a nationwide InSAR capture programme, generating imagery in 12-day epochs from 2017 through to 2026. Paired with GNSS observations from continuously operating reference sites (CORS) over the same period, this dataset offers a level of spatial and temporal detail that simply wasn't available when the current deformation model was built. InSAR provides dense spatial and discrete temporal coverage across the country, while CORS delivers precise, continuous and essentially absolute time series at specific points, together they give us a unique temporally and spatially high-resolution window into immediate coseismic signals, post-seismic decay and plate motion.

The combined dataset has been used to develop a new deformation model that increases resolution roughly tenfold, from a 0.1° grid (~10 km²) to a ~1 km² grid, and introduces a vertical component, something previously considered too challenging to model. The model is evaluated through simple bi-linear interpolation of the four nearest InSAR points around a given CORS site and can be assessed against how well it matches the GNSS data actually observed at the CORS site. This gives good insight into how well the model is likely to perform across the broader region.

Recovering CORS positions across 2017-2026 by adjusting their position annually using GNSS data with the standard model versus the new model, we get the following significant and fairly consistent reductions in their horizontal coordinate motion: KAIK (~91%), CLRR (~97%), HANM (~87%), TENN (~87%).

Current and emerging tsunami monitoring technologies for New Zealand

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Tsunami hazard can be widespread and have a variety of origins; notably earthquakes (most common), landslides and volcanic eruptions. Monitoring technologies have been designed and deployed to quickly assess the generation of a tsunami, its propagation towards populated coasts, and its landfall: both in the ocean and in lakes and fjords.

The most common devices used to monitor tsunami sources are seismometers, accelerometers and GNSS stations which enable the location, magnitude and mechanism of potentially tsunamigenic earthquakes to be characterised. These pair with sea-level monitoring capabilities like DART systems and coastal gauges to directly sense ocean surface fluctuations associated with tsunami. Although these technologies are useful and robust, each has limitations which restrict their utility and breadth of installation and some carry significant costs which can make their use impractical.

The last two decades have seen new technologies progressively emerging to try fill these gaps such as commercial submarine cables equipped with geohazards-dedicated SMART nodes, distributed (DAS) or integrated (optical interferometry) techniques using optical fibre physical properties and behaviours, satellite altimetry, onshore beam radar, ionospheric disturbances monitoring using GNSS networks, and hydrophones for monitoring non-earthquake sources of tsunami.

This poster highlights the advantages and drawbacks of these new capabilities and their potential future evolution into tsunami early warning and data collection capabilities usable for Aotearoa New Zealand. These are compared to tsunami monitoring technologies currently in use by GeoNet with comment on how these might be improved to support tsunami early warning capabilities.

The multi-hazard warning challenge: integrating science, communication, and decision-making

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Aotearoa New Zealand faces a complex hazard environment where geological, meteorological, hydrological, and environmental hazards can occur simultaneously, cascade, or compound over time. Supporting effective action in these contexts requires multi-hazard early warning systems (MHEWS) that help people understand risks and make timely decisions.

This presentation draws on a national review of New Zealand's multi-hazard warning landscape, including a stocktake of warning products and services, post-event reviews from the Auckland Anniversary floods and Cyclone Gabrielle, stakeholder needs analyses, international practice, and Māori priorities for early warning systems. The review examines how hazard information is communicated and used during complex multi-hazard events.

Findings show that while New Zealand has strong hazard monitoring, modelling, and forecasting capabilities, warning systems have largely evolved within hazard-specific and organisational silos. During multi-hazard events, users often need to combine information from multiple platforms, products, and agencies to develop a coherent understanding of risk. Post-event reviews highlighted how fragmented warning systems can contribute to inconsistent messaging, uncertainty about consequences, and challenges for decision-makers, communicators, and communities.

The recent formation of Earth Sciences New Zealand, and pending acquisition of MetService, creates new opportunities to better align hazard science, monitoring, and forecasting capabilities across multiple peril domains in support of a more integrated national multi-hazard warning system. This alignment could help improve consistency across warning products, strengthen communication of uncertainty and impacts, and support user-centred approaches to warning design alongside, and in support of, existing warning providers, emergency management agencies, and iwi and hapū.

From forecast to action: designing time-dependent tsunami forecasts for emergency decision-making

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Advances in tsunami modelling are enabling time-dependent forecasts that provide information on how tsunami threats are expected to evolve through time, creating new opportunities to support emergency management decisions. However, the value of these forecasts depends on how well they align with user needs and communicate uncertainty. We present the findings of a qualitative investigation in which we interviewed 17 tsunami scientists and emergency managers in Aotearoa New Zealand to explore how time-dependent tsunami forecasts could support response decisions. Based on a prototype forecast product we provided in the interviews, participants discussed information needs, usability, uncertainty, and decision relevance.

Results show that tsunami response is highly time-sensitive, with decisions focused on who should act, when action is required, and how long protective measures should remain in place. Participants saw clear value in time-dependent forecasts, provided they are delivered rapidly enough to support operational decision-making. A key challenge was communicating forecast uncertainty, particularly around critical impact thresholds used to guide response actions. While emergency managers expressed a relatively high tolerance for uncertainty, participants from both emergency management and science groups highlighted the need for transparent communication of forecast updates and how observational data are incorporated into evolving model outputs.

Our findings demonstrate the importance of user-centred approaches for bridging advances in geoscience forecasting and emergency management practice. We discuss implications for the design and evaluation of operational forecasting tools, highlighting how forecast products can better support understanding, interpretation, and decision-making in dynamic hazard contexts.

Why the Kaimanawa Wall is a man-made feature

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In the mid-1990s, New Zealand archaeologist Barry Brailsford and American David Childress examined a reputedly man-made wall in one of the most remote places in the centre of the North Island. They proclaimed it was undoubtedly man-made, probably by a pre-Polynesian culture (Waitaha), similar to that which left megalithic structures elsewhere in the Pacific and South America. In 1996, archaeologist Neville Ritchie and geologist Peter Wood declared that the wall was a natural exposure of ignimbrite with vertical and horizontal cooling joints giving the impression of giant man-made blocks. But even today, there are still many who visit the site and come away convinced the wall is man-made and old.

There are many reasons why this is so, but the main one is that the wall is a fresh, vertical face with a depression rather than weathered scree in front. It clearly appears to be a man-made feature. The public have been distracted by the natural orthogonal jointing pattern in the ignimbrite exposure and ignore the obvious clues to how the “wall” was formed. It certainly is not an ancient, buried, megalithic pyramid as some claim, but it is the back wall of a 1930s quarry where fresh blocks of ignimbrite were extracted to help build a forestry road. This explains why the wall is beside the road with the depression in front being blocks were lifted out. Subsequent earthquakes, rain and unsanctioned digging have resulted in some blocks in the wall moving apart and one part of the wall collapsing exposing the massive natural ignimbrite that forms the spur.

Case closed, except there is a surprisingly large number of “cooker conspiracy theorists” out there who will always claim otherwise.

Hayward BW 2025. Why do so many people think the Kaimanawa Wall is man-made? Because it is. Geocene 41: 18-21.

Thermodynamic modeling of CO_2–H_2O mixtures in geothermal reservoirs using a lumped parameter model

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Reinjecting dissolved carbon dioxide (CO_2) into geothermal reservoirs is seeing steady adoption within the industry. However, depending on where the CO_2 migrates to, it may alter thermodynamic stability conditions and induce boiling in water that would otherwise exist in a liquid condition. This, in turn, could increase pressure within the system and allow free gas to accumulate under caprock.

In this study, we compare the behaviour of pure water and binodal mixtures of H_2O-CO_2 in a lumped parameter model (LPM) framework as an efficient, reduced-order approximation of a geothermal reservoir. We used the IAPWS95 equation of state to model the phase boundaries and properties of pure water, and the modified Spycher-Pruess (SP) model for H_2O-CO_2 mixtures. The LPM is formulated in terms of the conservation of H_2O, CO_2, and energy, and includes source terms for recharge, conduction, and well operation.

We examine a range of CO_2 reinjection scenarios and how they modify boiling and pressure changes during concurrent geothermal injection and production. Boiling can be induced either through heating, pressure drop, or sufficient enrichment in CO_2. Whether these conditions are actually realised depends on the initial starting condition, the magnitude of the forcing on the geothermal reservoir, and the strength of its restoring fluxes like recharge and conductive losses.

Assimilating thermal, seismic and visual monitoring data into machine learning models for short-term eruption forecasting at Lascar Volcano, Chile

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Identifying the onset of transitions in volcanic behaviour, particularly the shift toward eruptive activity remains the central objective of volcano monitoring. Traditionally, approaches have largely relied on models motivated by underlying physics of eruption that assume geophysical precursors will manifest consistently across successive signs in volcanic state, assumption that often breaks down given the diversity of eruptive mechanisms, changing monitoring conditions or wrong assumptions about the physical processes.

Machine learning (ML) has emerged as an alternative uncovering hidden patterns relationships within in seismic and multivariate volcanic datasets. However, ML approaches to eruption forecasting have mainly focused on seismic data, with comparatively limited integration of other monitoring parameters to capture interactions among different manifestations of volcanic unrest. This presents an opportunity to extend these methods by incorporating observations, particularly in magmatic and hydrothermal systems where precursor signals vary markedly in timescale and amplitude.

Given its recent eruptive history and thermal anomaly record, Lascar volcano in northern Chile represents a good case study for evaluating how multi-parameter data can strengthen forecasting models. This study used random forest classifier specifically for this Volcano by integrating seismic data with satellite-derived thermal anomalies, ash-emission observations, and plume-height records from approximately a decade of monitoring. We build on a ML model initially developed for Whakaari by adapting the framework to Lascar Volcano and expanding it to assimilate additional data, including satellite-derived thermal anomalies, ash-emission observations, and plume-height records alongside seismic data.

We will explore whether combining thermal data with seismic measures will improve forecasting skill relative to seismic data alone. This is motivated by observations that long-term thermal unrest often precedes eruptive activity at active systems. Anticipated challenges to address are on integrating heterogeneous monitoring datasets (e.g., thermal, seismic, and visual-emission observations) within ML forecasting frameworks, including differences in temporal resolution, data availability, and signal characteristics.

Following the clues: analytical facilities supporting geothermal science at Earth Sciences New Zealand, Te Whatu Ao

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Earth Sciences New Zealand (Te Whatu Ao) builds on a scientific legacy originating in the New Zealand Department of Scientific and Industrial Research (DSIR), bringing together leading expertise in geochemistry, isotope science, environmental tracing, groundwater dating, atmospheric research, marine sciences, and geothermal monitoring. By integrating these complementary capabilities and state-of-the-art facilities within a single organisation, Te Whatu Ao provides a unique analytical platform capable of addressing questions from mantle processes to atmospheric change.

Stable isotopes are essential for characterising geothermal systems, helping to identify magmatic or deep CO_2 inputs, distinguish between biogenic and thermogenic CH4 sources, trace sulphur processes, and identify the origin and evolution of geothermal fluids and hydrothermal minerals.

Radiocarbon measurements facilitate the constraint of fluid origins and apportionment of carbon sources and residence times, providing key information on reservoir dynamics and long-term sustainability of geothermal resources.

Tritium enables tracing of geothermal water sources and movement, as well as determination of reservoir recharge, mixing rates and circulation, while noble gas abundances and isotope ratios provide insights into geothermal heat sources, activity, fluid mixing, and subsurface degassing/boiling.

Our analytical data informs the operation of geothermal plants processing hundreds of thousands of tonnes of geothermal fluid each day, supporting the management of corrosion, well scaling, and turbine degradation. Specialised laboratories support domestic and international geothermal operators in the monitoring and optimisation of established fields and evaluation of reservoir chemistry during new developments.

Additionally, ESNZ supports GeoNet and the National Groundwater Monitoring Programme through routine monitoring of geothermal surface features and volcanic crater lakes, and assessment of groundwater quality and trends.

By combining world-class analytical science with deep domain expertise, ESNZ Te Whatu Ao provides a unique platform for understanding complex hydrogeological investigations in geothermal monitoring and resource management, while fostering technical innovation and collaborative research that underpins New Zealand’s future.

Constraining prehistoric rock avalanche occurrence using paired $^{10}Be/^{36}Cl$ cosmogenic surface exposure dating in New Zealand greywacke

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Large rock avalanches (>1 million m^3) are a primary agent of erosion and sediment generation, meaning the rate of large rock avalanche occurrence is crucial for quantifying downslope mass movement, as well as hazard. However, because landslides typically accumulate in the path of rivers and glaciers and eroded, few large prehistoric rock avalanches have been identified and dated in New Zealand, limiting understanding of their influence on long-term landscape evolution and hazard. The 20 million m^3 Coal River rock avalanche (CRRA) in Canterbury, New Zealand, is a previously unstudied, seemingly old, preserved deposit primed for both expanding the dataset of dated palaeo-landslides in New Zealand and developing geochronological techniques. Paired $^{36}Cl/^{10}Be$ cosmogenic surface exposure dating of boulder samples collected from the rock avalanche surface determine the age of the deposit, which tests the applicability of ^{36}Cl cosmogenic nuclides in Rakaia Terrane Torlesse greywacke. Sediment samples taken both from within the in-situ rock avalanche deposit, and in reworked sediments downstream, have been processed for detection of agglomerates – particles with microsediment textures unique to high-energy comminution processes such as rock avalanches. Combining well-constrained surface exposure dates and geomorphological mapping with quantitative analysis of agglomerate abundance along the avalanche path develops understanding of how rock avalanche signatures may be preserved in the geological record. This addition to the New Zealand dated palaeo-landslide record contributes to improved understanding of rock avalanche initiation and preservation.

IntChron and TephraNZ, a plotting and data handling tool collaboration

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IntChron (Smith et al., in press) is a free, open access, online platform for storing, sharing, comparing and visualising tephra geochemistry and chronology. It has been developed by the University of Oxford in collaboration with the international group “INTIMATE” (Integrating ice core, marine and terrestrial records). The tool allows users to upload structured data files. These data are then able to be plotted interactively on geochemical biplots, an age timeline, and a map. This allows datasets to be overlain and compared from different studies in a fast and visually appealing way.

Here we present an overview and worked example of the platform used for the first time in Aotearoa New Zealand using the TephraNZ database as the data source. We will step through the data set up, input, and show an exploration of what the tool can be used for, including but not limited to mapping, TAS (total alkali plus silica), biplots (major and trace element geochemistry), and PCA analysis.

A multiscale framework for quantifying shore platform lowering using Micro-Erosion Meter, hierarchical statistical modelling, and satellite geodesy

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Rock shore platforms evolve through interactions among marine erosion, weathering, tectonic processes, and sea-level change, yet quantifying their evolution across spatial and temporal scales remains challenging. This study integrates long-term Micro-Erosion Meter (MEM) observations, hierarchical statistical modelling, Global Navigation Satellite System (GNSS) measurements, and Persistent Scatterer Interferometric Synthetic Aperture Radar (PSI-InSAR) to investigate shore platform lowering across two contrasting settings: the tectonically active Kaikōura Peninsula, New Zealand, and the tectonically stable Otway coast, southeastern Australia. At Kaikōura, eight years of post-earthquake MEM observations (2017–2024) analysed using robust and location–scale mixed-effects models reveal strongly hierarchical downwearing variability, with greatest heterogeneity at the MEM point scale. Mean post-seismic downwearing was 2.10 mm/yr, with significant controls from elevation, time since uplift, cross-platform position, and morphological setting. At the Otway coast, analysis of a 13-year MEM record (2011–2024) using robust linear mixed-effects, piecewise mixed-effects, and hierarchical autoregressive AR(1) models reveals spatial hierarchy, temporal dependence, and non-linear downwearing behaviour, with episodic high-magnitude events representing transient rather than sustained trends. Integration with GNSS-calibrated PSI-InSAR extends these field observations spatially. At Kaikōura, PSI captures similar spatial patterns to MEM-derived downwearing while also reflecting broader post-seismic deformation. At the Otway coast, combined MEM, GNSS, and PSI observations distinguish platforms characterised by comparable geomorphic and geodetic lowering from those showing greater geodetic surface displacement. Together, these results provide a multiscale framework for integrating field measurements, hierarchical statistical modelling, and satellite geodesy to quantify rock coast evolution and improve understanding of shore platform response across contrasting tectonic settings.

Terrestrial runoff and impacts on coral reefs: northwest Borneo, Malaysia

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Tropical coral reef ecosystems sustain the livelihoods, food security, and coastal protection of an estimated one billion people globally, yet face accelerating degradation from terrestrial runoff, sedimentation, and climate-driven bleaching. Reefs within Tunku Abdul Rahman National Park (TARP), Sabah, Malaysian Borneo, are situated at the epicenter of the Coral Triangle and currently classified as being in poor condition, represent a critically under-investigated system with respect to terrestrial sediment delivery and its influence on reef carbonate facies composition. This study investigates terrestrial runoff impacts on the isolated fringing reef systems of Sapi, Mamutik, and Sapphire Islands within TARP through an integrated multi-method approach comprising field geomorphological surveys, sedimentological analysis, compositional petrography, alteration index quantification of reef sediments, and satellite-imagery-based environmental facies mapping. Seven distinct environmental facies were identified and mapped across both siliciclastic and carbonate reef domains. The siliciclastic facies group comprises foreshore beach, rocky substrate, and subtidal sand environments, occupies 50% and 11% of the mapped area at Sapi and Mamutik, respectively, with siliciclastic content ranging from 0.5% to 66%, abundant reworked shell allochems (8%–40%) and coral fragments (26%–78%), and evidence of intense abrasion and bioerosion. The carbonate reef facies group, encompassing outer reef slopes, reef flat networks, and patchy rubble zones, dominates 50% and 89% of the mapped area at Sapi and Mamutik, respectively, with carbonate clast contents of 21%–37% and coral contributions of 50%–70%, but measurable siliciclastic infiltration (0%–27%) even within reef-dominated zones. These siliciclastic-fringed reef islands are demonstrably distinct from equatorial carbonate reef systems, characterised by elevated nearshore clastic input, absence of seagrass beds, and spatially variable terrestrial sediment penetration into carbonate facies. The findings establish a critical sedimentological baseline for monitoring ongoing terrestrial impacts and informing reef management policy within this globally significant marine protected area.

High resolution videography constrains causes of complex lava fountaining dynamics at Kilauea volcano

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Lava fountains are a low-energy form of sustained, generally basaltic, explosive eruptions. They are spectacular and among the most common styles of volcanism worldwide, posing significant hazards to visitors and infrastructure. The physics of lava fountains are most strongly influenced by two factors: magma rheology and complex patterns of release of dissolved gas (degassing/outgassing) from the magma both prior to, and during, fragmentation. We recognize two bubble populations in rising Strombolian and Hawaiian magma: (i) numerous small bubbles (generally sub-centimetre) which remain mechanically coupled to the host magma on the time scale of ascent of magma from shallow storage, and (ii) larger bubbles (decimetre – metre) that can rise buoyantly and independently of their host fluid. Interaction of these subpopulations contributes greatly to the form of the resulting eruptive activity.

Phase i (in an absence of phase ii bubbles) produces steady, stable lava fountaining involves bubbly flow of rising buoyant, relatively fluid melt through a dike-or-pipe shaped conduit. Rapid, in-situ, shallow expansion of the entire small bubble population tears the magma into fluid clots and droplets. The fragmentation begins at the free surface but can continue within the fountain due to fluid/fluid instability.

The addition of phase ii to phase i drives unsteadiness of the resulting fountains, manifested as pulses recorded in the fountain height and pyroclast velocities. (In contrast Phase II bubbles rising through slow moving or stagnant melt produce Strombolian discrete explosions.)

A Late Quaternary reconstruction of the sedimentary processes and environments associated with the Rapanui Formation at Waiau Stream, Taranaki

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The northern Taranaki coastline comprises of vertical cliffs that preserve a Miocene-age deep-marine sedimentary record, unconformably overlain by the late Quaternary Rapanui Formation. The Rapanui Formation was formally named by Fleming in 1946 as the cover of the Rapanui Terrace, a late Pleistocene marine terrace west of Whanganui. It is widely interpreted as being deposited upon a wave-cut platform during the Last Interglacial (120-115 ka) when sea levels in Taranaki were 5-6 m higher than present-day. Yet, sedimentary processes and sedimentation controls of the Rapanui Formation are poorly understood. Using field, laboratory, and desktop analyses, this research explores the lateral and vertical extent and variability of units across Waiau Stream in northern Taranaki. Preliminary analyses show that: (a) many beds are laterally variable, with several pinching in and out of the wider outcrop; (b) beds show vertical variability on the wider outcrop; and (c) sediment sources varied through time. At its maximum, the formation is ~10-12 m thick, with a minimum of ~2-3 m thickness, particularly in areas adjacent to the modern stream. A highly heterogenous succession of mixed unconsolidated lithologies including conglomerates, sands, silts, and clays was observed, with a predominant westward paleoflow direction based on imbrication and paleocurrent-indicators. Moderate-to-high energy (lower flow regime) cross-bedding records migration of subaqueous dunes, with interbedded gravel-cobble-dominated conglomeratic interbeds. Moderate-to-lower energies were recorded in sand, silt, and clay successions, most not showing any grading. Some fluvial conglomerates and sand beds are present with normal grading, representing decreasing energy or pulses of sediment transport. Stream position varied through time, fluctuating from west to east, with clear paleotopographic lows identifying previous positions of the stream. Paleo-highs in topography are mostly explained from volcanic influences, through influx of debris-avalanches. All these elements contribute to constraining the processes controlling sedimentation of the Rapanui Formation at Waiau Stream.

Diffusion-based machine learning for clustering earthquakes in the Taupō Volcanic Zone

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Earthquake monitoring is an essential tool for volcanic eruption forecasting. Volcanic eruptions are often preceded by a sudden increase in seismicity beneath or near a volcano. Even small changes in stress at active volcanoes can trigger seismicity and, in some cases, eruptions. A common challenge in volcanology is identifying patterns and underlying relationships in earthquake occurrence. However, current machine learning-based earthquake clustering methods rely on distances between earthquakes and often struggle to accurately capture complex nonlinear spatiotemporal relationships.

This study investigates diffusion-based machine learning as an alternative approach to clustering earthquake catalogues. Inspired by non-equilibrium thermodynamics, diffusion models learn complex patterns in data by gradually adding random noise and training a model to reverse this process, thereby recovering the underlying structure. Although best known for image generation, diffusion models have recently shown promise in unsupervised clustering. We adapt an existing diffusion clustering architecture originally developed for image data into a pipeline for multivariate time-series earthquake data. The proposed method first encodes overlapping windows of earthquake observations into latent representations and then applies diffusion-based clustering to identify patterns of seismicity.

We evaluate the developed method using earthquake data from the Taupō Volcanic Zone. Results from diffusion-based clustering are compared to known episodes of volcanic unrest and geological features, including volcanic systems and geothermal reservoirs. We examine the temporal, spatial, depth, and magnitude characteristics of the resulting clusters and assess their sensitivity to key model and windowing hyperparameters. This research investigates whether diffusion-based clustering can reveal geologically meaningful patterns in volcanic seismicity and provides a foundation for applying diffusion-based deep learning to earthquake monitoring and natural hazards research.

Perceptions of multi-hazard risk, impact, and mitigation: the challenge of consistent language.

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Aotearoa New Zealand is an island nation which regularly experiences a range of natural hazard events, including earthquakes, tropical cyclones, volcanic eruption/geothermal activity, torrential rain, flooding, tsunami, wildfires, drought, landslides and snowstorms. Many natural hazard events give rise to multiple hazards, including cascading, coincident and compounding hazards. Communication in a multi-hazard context is challenging; therefore, it is important to understand how individuals conceptualise factors that lead to individual or multi-/cascading/coincident hazards, their effects and impacts, and mitigation actions that can be taken. This research sought to understand how individuals conceptualise hazards and risk in such multi-hazard contexts, to identify lessons to improve associated risk communication. Additionally, it explored commonalities and differences in perceptions, needs, and interests between hazards, as well as understanding of associated terminology. A qualitative survey was deployed using Qualtrics in 2021 with a total of 237 usable responses received. Responses were coded and analysed using a descriptive conceptual content analysis. Six key findings emerged:

- there was some terminology confusion;
- respondents were most familiar with earthquakes;
- droughts were seen as controllable and to affect a specific sector of society;
- impacts were emphasised more than processes;
- perceived control and fatalism varied by hazard type; and
- there were different societal vs personal framings of responses.

The results also suggest that earthquakes, and their impacts (plus how to mitigate them), are well understood but that other natural hazards, like volcanic eruptions and drought, are not – and this will affect people's responses to and preparedness for events like these.

Sliding lands, solid decisions: Integrating landslide hazard and risk information into practice.

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Aotearoa New Zealand's steep terrain, high rainfall, and seismic activity make landslides a widespread and growing hazard—exacerbated by climate change. Events like Cyclone Gabrielle (2023) and the Kaikōura earthquake (2016) have shown the devastating impacts on communities. To support effective planning and resilience, we need consistent, decision-ready information on where and when landslides occur, who and what is exposed, and the potential consequences.

Currently, landslide hazard and risk data are fragmented. The Hōretireti Whenua / Sliding Lands Programme addresses this gap by developing nationally applicable models for fast-moving landslides triggered by rainfall and earthquakes. These models are designed to support planning decisions by acting as both screening tools, pinpointing areas where more detailed assessment is needed, and risk-informed decision tools in high-risk areas.

The programme integrates three research pillars:
1. Social Science – builds frameworks to support communication and use of landslide information across diverse users.
2. Hazards – develops the National Rapid Landslide Hazard Model (NRLHM) to produce consistent hazard footprints and identify hotspots.
3. Impacts – expands knowledge on landslide consequences and ensures robust analysis of landslide risk.

Together, these pillars ensure the models are not only scientifically robust but also usable and defensible in difference decision contexts. In this presentation we will showcase recent insights from across the social science pillar as we seek to improve the uptake and decision-relevance of these models.

Development of simulation exercises to strengthen geohazard response capability

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New Zealand is exposed to a wide range of geohazards, including earthquakes, tsunamis, volcanic eruptions, landslides and severe weather events. Compared with other geohazards, the occurrence of large earthquakes with tsunamigenic potential are rare in New Zealand. This makes preparing for large scale responses difficult. Simulation exercises provide a safe environment to test systems, strengthen coordination and build organisational readiness before a major event occurs.
At Earth Sciences New Zealand, we have developed a progressive exercise programme ranging from tabletops to quarterly functional exercises and annual organisation-wide simulations. These exercises are designed to strengthen both scientific and incident management capability, while testing the interaction between scientific monitoring teams, expert scientists, expert panels, and the Incident Management System (IMS).

In March 2026, we ran exercise Parawhenua, an organisation-wide exercise to test how science and response teams would work together following a Mw8.89 Hikurangi Subduction Zone earthquake and tsunami, and a Mw7.7 aftershock event. The scenario was designed to introduce increasing operational complexity, requiring participants to continually interpret evolving scientific information while supporting operational decision-making. During the 3-hour exercise, approximately 60 people participated from the National Geohazard Monitoring Centre, the Tsunami and Earthquake Expert panels, and IMS response functions worked together to analyse simulated data, develop scientific advice and coordinate the organisational response.

Following the exercise and debrief, we were able to identify the areas of the system which were well prepared and areas which need further training. Here we present the development of the exercise scenario and scientific injects, the approach used to integrate scientific and incident management functions, key lessons identified through the exercise, and how these findings are informing, standard operating procedures, as well as future capability development exercising across Earth Sciences New Zealand and New Zealand National Emergency Management system.

Investigating and communicating the tsunami hazard posed by sub-aerial landslides on Whakaari/White Island

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Landslide generated tsunami pose a significant threat to some sections of New Zealand's coastline. The Te Moana-a-Toitehuatahi/Bay of Plenty coast could be impacted by tsunamis generated by sub-aerial landslides from Whakaari/White Island. Using the geophysical models of Whakaari's structure and stability, developed in the Beneath the Waves Endeavour research programme, we have developed models of potential landslides that could occur along the flanks of Whakaari/White Island. From these models, we selected 65 scenarios, from 13 source locations around the island (five in each location) and modelled the resulting landslide and tsunami using COMCOT. For each landslide scenario, while the dynamic mass failure process was only modelled in the first five minutes, the landslide tsunami was continuously simulated for up to three hours to ensure the capture of maximum tsunami heights at the coast across the Te Moana-a-Toitehuatahi/Bay of Plenty and eastern Waikato regions. From these models we investigated the maximum potential tsunami heights generated, the characteristics of the tsunami waves, the tsunami travel times and the probabilistic tsunami hazard.

The modelled results showed that wave heights up to 30 m could be generated close to Whakaari, maximum coastal waves heights were modelled to be between a few tens of cms to 6m along the Te Moana-a-Toitehuatahi/Bay of plenty coastline. We found that compared to earthquake generated tsunami, land inundation was limited, due to the short wave period of the tsunami waves, but travel times are shorter potentially reaching the coast in less than 20 minutes. We discussed these results with emergency management agencies, working with them to provide useful outputs to convey the hazard to the general public, ultimately, enhancing regional coastal resilience.

The earthquake-induced landscape dynamics Endeavour Programme: recap, findings and future directions from the 2016 Kaikōura Earthquake

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Ten years after a major earthquake, the landscape remains an active record of both the initial seismic disturbance and the cascading processes that follow. The Earthquake-Induced Landscape Dynamics Endeavour Programme has shown that earthquake-induced landslide hazard cannot be understood from shaking intensity alone, but through the combined effects of geology, geological structure, terrain condition, landslide mechanism, rainfall response, and sediment transfer from hillslopes to channels and rivers.

Over the past decade, advances in regional terrain differencing, multi-temporal 3D and 4D analysis, InSAR time-series techniques, field monitoring, laboratory testing, and numerical modelling have improved our ability to map landslides, quantify sediment production, and identify slow-moving or reactivated slopes. These approaches have also highlighted persistent uncertainties, including the legacy of earthquake-cracked rock masses, the influence of fault-damage zones, the longevity of landslide dams, the timing of post-earthquake rainfall-triggered failures, and the downstream impacts of delayed sediment release.

Looking back over ten years of research, a central lesson is that post-earthquake hazard is both long-lived and path dependent. Future progress will require pre-established observatories, systematic repeat lidar and remote sensing, connected landslide inventories, and physics-informed models that explicitly represent landscape evolution through time. Equally important is stronger integration of science with planning, legislation, and residual-risk management.

By linking observations and models across slopes, catchments, channels, and rivers, the next phase of research can deliver practical tools to reduce the social, economic, and environmental impacts of future earthquakes and their long-term consequences.

Snow geochemical survey as the best method for assessing air quality in winter regions.

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Snow cover accumulates pollutants as they are washed out of the atmospheric air. Concentrations of substances in snow cover are several times higher than in the air, and they characterize the typical, rather than instantaneous, state of the atmosphere. This makes snow geochemical surveys the most informative method for studying atmospheric quality in regions with long, snowy winters. However, there are problems that prevent this method from being used as a basic method in environmental monitoring: pollutant concentration maps do not characterize either the degree of environmental hazard or the level of anthropogenic load; background geochemical parameters of snow in many regions of northern Eurasia have been studied only fragmentarily. The authors' research aims to develop an effective method for assessing air quality for both environmental monitoring and environmental studies within new projects. Ranges of anthropogenic and natural variability in pollutant concentrations in the air of industrial areas and background natural areas in northern Eurasia have been established. To this end, students and professors at Irkutsk Polytechnic University have been compiling a large database over the years. They are studying the chemical composition of solid residue and snow water, and comparing median and maximum concentrations between different objects in different areas. This makes it possible to determine whether anomalies are natural or artificial. A methodology for geoinformation mapping of air quality based on the obtained data is presented and substantiated, allowing for assessment of atmospheric conditions. The main results of the study are publicly presented in map form, allowing for comparison of identified pollution areas with locations of interest, on the Irkutsk National Research Technical University's geoportal, the Siberian School of Geosciences (geo.istu.edu).

An initial assessment of the temporal variability of the Sri Lankan geodetic reference frame

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The Sri Lanka Datum 1999 (SLD99), realized through the International Terrestrial Reference Frame 1992 (ITRF92), provides the national geodetic reference framework for surveying, mapping, engineering, and other geospatial applications in Sri Lanka. Sri Lanka is located in the relatively stable interior of the Indian Plate. However, long-term tectonic plate motion, regional tectonic processes, and significant earthquakes can cause variations in geodetic coordinates when expressed in a global reference frame, both spatially and temporally. With the increasing reliance on Global Navigation Satellite Systems (GNSSs) in high-precision positioning, continuous monitoring of tectonic and seismic activities is essential to support the long-term maintenance and modernization of the national geodetic reference frame. This study presents a preliminary assessment of the temporal variability of three-dimensional coordinates using decadal (2011–2020) GNSS observations from the Sri Lanka Continuously Operating Reference Station Network (SLCORSnet), referenced to selected International GNSS Service (IGS) stations, aligned with ITRF2020. Preliminary results indicate that the six SLCORSnet stations (AWIS, CLMB, KALU, KATA, KEGA, and RATH) exhibit a consistent north-eastward motion with an average horizontal velocity of 58 ± 0.1 mm/year (95% confidence interval, C.I.) while maintaining millimetre-level horizontal coordinate precision. Although variability is observed among individual station velocities, these differences are likely associated with variations in observation periods. The regional IGS reference stations (HYDE, IISC, and SGOC) display comparable north-eastward motion, with an average velocity of 56 ± 0.1 mm/year (95% C.I.), reflecting the long-term kinematics of the Indian Plate and providing a stable reference framework for regional GNSS analyses. Overall, these findings demonstrate the capability of continuous GNSS observations to quantify temporal three-dimensional coordinate variability and evaluate the stability of the Sri Lankan Geodetic Reference Frame, providing a scientific foundation for development of a time-dependent national geodetic reference frame and improved monitoring of long-term tectonic and earthquake-induced deformation in Sri Lanka.

Advances in rapid characterization of local earthquakes and tsunami: From the 2016 Kaikōura earthquake to now and beyond

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Ten years on from the Kaikōura earthquake, we reflect on advances in New Zealand's scientific ability to rapidly respond to large local earthquakes.

Time-critical science response to earthquakes and tsunami is challenging, particularly for local events that may generate tsunami. Initial uncertainties are high. Scientific information is incomplete and evolving dynamically through time. Yet situational awareness of the potential impacts is critical for saving lives and improving recovery.

The 2016 Mw7.8 Kaikōura earthquake highlighted many of these challenges. It's first representation was a dot on a map, with an underestimated magnitude. Yet, the earthquake was large and notoriously complex, rupturing 20+ faults onshore-offshore from northern Canterbury to the Cook Strait, and generating severe shaking, widespread landslides, and a tsunami with run-up up to ~7m. At the time of the event, the extent of shaking, tsunami, landslide and building damage was unclear, even hours to days into the response.

Since then, we have been significantly expanding rapid scientific information, through development of real-time rapid characterization of earthquake and tsunami (RCET) tools, in partnership with operational advances in GeoNet, including the establishment of the 24/7 Geohazards Monitoring Centre. In near real-time, we can now review available earthquake solutions and focal mechanisms, flag tsunami potential, estimate rupture extent, rupture propagation direction, areas of strong ground shaking, impacted urban centres and exposed population, as well as map the spatial extent of aftershocks. The combination of real-time tool implementation, on-hand specialist expertise and interpretations, and wider science expertise co-ordination through the GeoNet Incident Management System (IMS) significantly speeds up and the generation of time-critical bespoke event advice.

Key scientific challenges remain, particularly in the treatment of uncertainties, estimation of extent and severity of local tsunami, tsunami inundation and multi-hazard impacts. These are also a focus of the next 5 years of the RCET programme (RCET-NEW).

Surrogate-assisted optimization for geothermal reservoir model development.

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Geothermal reservoir simulation is a valuable tool for simulating reservoir behaviour to support sustainable resource development. It involves developing numerical models that simulate subsurface fluid and heat transport and calibrating them with observations such as downhole measurements. These reservoir models include uncertain parameters (representing physical properties of the reservoir) and complex coupled processes, making simulations computationally expensive. This limits the exploration of the uncertain parameter spaces and the identification of model configurations that adequately reproduce observed reservoir behaviour.

We investigate a surrogate-assisted optimization framework that combines conventional physics-based reservoir simulation with machine-learning surrogate models to accelerate parameter exploration. An initial set of high-fidelity simulations is generated across the parameter space to provide training data for surrogate models that learn about the complex relationship between reservoir model parameters and the resulting model behaviour. Our current implementation evaluates Gaussian Process and Random Forest surrogate models, with the framework designed to accommodate more advanced AI or combined approaches in future development. The trained surrogate rapidly evaluates thousands of candidate parameter combinations at much lower computational cost than traditional reservoir modelling. A global-to-local optimization strategy is then used to identify promising candidate solutions, which are subsequently validated using the high-fidelity reservoir simulator.

Our preliminary results show the potential of surrogate-assisted optimization to match or exceed manual calibration by experienced modellers. This approach could accelerate the production of better calibrated reservoir simulations that reproduce observed field measurements such as pressures and temperatures. This framework provides a foundation for integrating emerging AI methods into physics-based geothermal reservoir models.

Near-field tracking of large earthquakes using CCTV footage.

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Our understanding of earthquake rupture dynamics remains limited by a scarcity of near-field observations. Important source properties, including local rupture speed and near-field ground velocity, are poorly constrained by conventional seismic observations. Here we demonstrate that closed-circuit television (CCTV) footage can be used to track rupture propagation and resolve first-order features of the near-field ground-velocity field. We analyse near-field CCTV footage from supershear (2018 Mw 7.5 Palu, 2025 Mw 7.7 Mandalay) and subshear earthquakes (2026 Mw 7.5 Venezuela 2026 Mw 6.8 Kumamoto) and validate the inferred ground motions using nearby strong-motion recordings. Our results show that horizontal ground accelerations exceeding 0.45 g are sufficient to decouple objects at rest from the underlying ground surface. By tracking the apparent motion of stationary objects relative to the moving ground surface, we show that such objects can serve as simple proxy strong-motion recorders. Using CCTV observations from more than 20 near-field locations along the 400-km-long Sagaing Fault, we determine the timing of peak horizontal ground velocity during the 2025 Mandalay earthquake. These measurements yield a constant rupture speed of 5.2 km s^{-1} from the epicentre to the southern rupture termination. These results demonstrate that dense networks of low-cost cameras can provide real-time constraints on rupture propagation, offering a new approach for rapid earthquake source characterization where cameras are deployed near active faults.

Groundwater-driven surface uplift in Greater Osaka, Japan, mediated by crustal faults.

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Urban land subsidence driven by groundwater extraction is widespread, but the processes governing how groundwater recovery translates into spatially variable surface uplift remain poorly understood. We use satellite geodesy and multi-decadal groundwater observations to measure vertical land motion in Greater Osaka, Japan, where aquifers are intersected by a dense network of crustal faults. We observe widespread surface uplift at rates up to 10 mm/year, organized into distinct domains separated by sharp boundaries. Uplift rates vary abruptly across domain boundaries, which coincide with mapped faults. Where no faults are mapped, abrupt spatial changes in uplift rate suggest the presence of previously unrecognized buried faults. Uplift rates are positively correlated with groundwater-level rise in wells screened at depths up to 600 m, while deformation modelling indicates dominant uplift sources are shallower than 500 m. Our analysis suggests crustal faults act as hydraulic barriers to lateral groundwater flow, localising vertical land motion during aquifer recovery, with implications for groundwater management, infrastructure stability, and land-use planning in urban basins worldwide

To the solidus…and beyond!: linking a subsolidus equation of state to a rhyolite-MELTS supersolidus equation of state

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The evolution of magma below the surface is a continuous avenue of research for volcanologists and petrologists. Much of the history of a magma is not captured in the final products that can be observed in the field and analysed in the laboratory. Computational thermodynamics bridge the gap between initial and final states of magma via calculation of states in between magma injection and eruption (or solidification and beyond).

Here, we detail a thermodynamic equation of state (EOS) that can characterize the evolution of a magma from liquidus to subsolidus conditions. Using initial whole-rock compositions, we employ the thermodynamic equilibrium engine rhyolite-MELTS to calculate phase assemblages and proportions, along with their thermodynamic properties, over a grid of temperature, pressure and H_2O. Our goal is to model isobaric cooling paths for magmas in the crust. The outputs describe magmatic conditions, while corresponding subsolidus conditions are determined using the final state of the crystallized magma and an EOS describing water. The resulting profiles are compiled into a 3D look-up table, creating an EOS indexed by specific enthalpy, pressure, and H_2O content of the magma.

This approach provides detailed constraints on the state of magma specifically when large amounts of crystallization occur across a small range of temperature (i.e., near-invariant or near-eutectic conditions). Additionally, the EOS tracks the evolution of the magma after it is fully solidified, allowing for calculation of general thermodynamic properties to temperatures that can approximate the geotherm. The framework could be expanded to consider additional components in the bulk volatile phase, which would have implications for our understanding of the impact that changes in magma can have on the surrounding crust. This framework also provides the ability to create modular magma body instances that can be used as input into a wide range of other numerical models.

Interpreting landslide susceptibility in practice: stakeholder perspectives from New Zealand

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Landslide susceptibility maps are increasingly used to inform planning and infrastructure decisions, yet how their information is interpreted and translated into practice may vary between professional users. This study explores how New Zealand practitioners perceive, interpret and use landslide susceptibility information. Preliminary analysis draws on 10 semi-structured interviews with stakeholders working across land-use planning, engineering, infrastructure, emergency management and forestry. Participants were presented with the same landslide susceptibility map within a hypothetical development scenario and asked to interpret the mapped classes, discuss their usefulness, limitations and credibility, and explain how the information would influence their judgement. Influence-diagram elicitation was also used to examine factors shaping interpretation and decision confidence. Preliminary findings indicate broad agreement that susceptibility maps are useful for identifying locations requiring attention or further investigation. However, participants differed in what they expected the mapped classes to mean in practice: some emphasised the technical basis, uncertainty, limitations of the model, and how they had been validated before relying on the output, while others interpreted the classes primarily through their implications for investigation, consenting or site selection. Similar patterns were identified in earlier interviews in Nepal, suggesting that variation in translating susceptibility information into practice may extend across different land-use and risk-management contexts.

4D assessment of mineral seal formation prior to phreatic eruptions

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The most common style of eruption at andesite volcanoes are gas-driven, with little to no magmatic material ejected. Pressurisation in the lead up to eruption can be subtle, centred beneath the eventual vent area and in the shallow surface. The postulated driver of pressurisation before a gas-driven eruption is the precipitation of hydrothermal minerals in the conduit. To understand the underlying processes, we reacted andesite granules with a highly acidic crater lake fluid. Our conceptual model seeks to recreate the reactions likely occurring due to ingress of crater lake fluid into fumaroles.

We conducted a series of experiments using a flow-through reactor at elevated temperature and pressure. The apparatus is fitted with titanium tubing, enabling experiments to be conducted at very low pH, recreating the conditions within volcano-hydrothermal systems. Our experiments initially use a relatively slow flow rate (1ml/hr), which was later increased substantially (up to 20 ml/hr) to explore precipitation kinetics. Lastly, we varied the run duration to explore the evolution of seal formation at ~10, ~30, and ~50 days.

Our results highlight three important factors: 1) as expected, porosity steadily decreases with time, albeit with connected pore networks that enabled continued flow until pressurisation and failure; 2) the mineral assemblage consists of alunite and/or natroalunite, anhydrite, elemental sulfur, and minor kaolinite; 3) the formation of a seal in our experiments is governed by the fluid volume up to 20 ml/hr (at ~2-2.5 l) and is therefore able to form over proportional timescales i.e., several days to several weeks.

Our results provide unique insights into hydrothermal system processes leading to phreatic eruptions. Modelling of our experimental data is eminently transferable to nature, and will help us develop a new understanding of the unrest in the lead up to these extremely challenging eruptions.

Fault scaling in magma-rich rifts

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Magma plays a major role in accommodating rift extension within magma-rich continental rifts, but its impact on fault seismogenesis is poorly understood. Observations of active rifting episodes require consideration of distinct fault-scaling coseismic displacement vs fault length for both magmatic vs amagmatic rifting episodes in extensional systems. For example, during the Dabbahu diking episode in 2005 (Afar, Ethiopia) the cumulative earthquake magnitude was lower than that estimated from the measured geodetic strain and observed fault displacement (>2 m). This complex interplay between magmatism and faulting thus complicates seismic source models developments for seismic hazard assessments in magma-rich rift systems (e.g., Taupō Volcanic Zone, New Zealand).

This study aims to develop a framework for understanding fault scaling relationships during magmatic rifting episodes. We will utilize published datasets from the Dabbahu-Manda-Hararo rift segment in the Afar Depression (Ethiopia), volcano-tectonic diking episodes in the Natron Basin (Tanzania), the Krafla rifting events episodes and other diking events in Iceland to calibrate and develop a fault-scaling model for magma-rich rifts. Data synthesis involves published field observations (e.g., fault offsets), seismicity, deformation derived from InSAR/ GNSS, optical imagery, LiDAR, dike intrusion and general fault-growth studies. These data will provide new fault displacement-length relationships, fault widths, dike length/widths, and coupling coefficients for a range of observed magmatic rifting scenarios. Results will contribute to refining seismic source models for seismic hazard assessments in magma-rich rift basins.

~~Keywords: Seismogenesis, continental rift, rift segment, fault-scaling, diking episode~~

A hybrid experiment to image the Taupō volcanic system with distributed acoustic sensing and seismic nodes.

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The Taupō Volcanic Zone (TVZ) hosts one of Earth's most productive silicic volcanic systems and remains a key target for understanding the links between magmatism, tectonics, and volcanic unrest. To improve seismological constraints on the crustal structure beneath Taupō volcano, we are conducting a six-month passive seismic experiment combining distributed acoustic sensing (DAS), temporary nodal seismometers, and the GeoNet seismometer network.

The DAS component makes use of approximately 30 km of dark fibre along State Highway 32 and owned by Chorus, supplemented by 11 temporary seismic nodes, and permanent broadband and short-period stations from the national network. Continuous observations are being collected over six months, which started in August 2026, with the intention of recording local volcanotectonic seismicity within the upper crust as well as deeper earthquakes associated with the Hikurangi subduction system. The combination of metre-scale DAS measurements with the wider aperture provided by conventional seismic stations and nodes provides enhanced resolution and coverage compared with either approach alone.

Planned analyses will integrate all available datasets to improve earthquake detection and relocation, generating a refined catalogue of seismicity across the Taupō region. These results will provide the basis for full-waveform inversion (FWI) aimed at resolving the geometry of the magmatic system and broader crustal structure. This contribution presents the experiment design, deployment details, and preliminary results, and invites discussion of potential collaborations and complementary datasets that could maximise the scientific value of this novel hybrid seismic experiment.

Experimental investigation of temperature-dependent CO_2 mineralization in epidote-bearing silicic geothermal reservoirs of the Taupō Volcanic Zone, New Zealand

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Carbon capture, utilization, and storage in geologic formations is becoming an increasingly attractive option for mitigating anthropogenic carbon dioxide production. Recent efforts have focused on sequestering CO_2 by injecting it into geological reservoirs for long-term storage. Ideally, CO_2-brine-rock interactions result in the formation of carbonate minerals, permanently storing CO_2 through mineral trapping. One target would be high-temperature geothermal reservoirs, as the infrastructure needed to inject CO_2 is already in place. Many power-producing geothermal fields are hosted in intermediate to silicic volcanic rocks, where the abundance and reactivity of Ca-bearing minerals may limit carbonate mineralization. However, epidote, a reactive mineral that can contain up to 15 wt.% Ca, is common in high-temperature geothermal fields and could provide the cations needed to form carbonates. To determine the effect of such reactions on silicic geothermal reservoirs, a series of CO_2-brine-rock reaction experiments assessing mineralogy, brine composition, and whole-rock petrophysical properties at temperatures from 100 oC to 200 °C, along with associated PHREEQC modelling, is underway. The target of our investigation is the Tahorakuri Formation in the Taupo Volcanic Zone, which was selected due to its prevalence within active geothermal fields, and the abundance of epidote (up to 14 wt.%). Initial results at 100 °C show that quartz was resistant to CO_2-acidified brine. At the same time, epidote dissolved preferentially relative to feldspar, resulting in reduced rock stiffness, as reflected by decreased P- and S-wave velocities. While permeability increases, likely due to more extensive dissolution along fluid-flow pathways, porosity remains unchanged. No carbonate formation has been observed thus far, it is expected to occur at experiments above 180 °C based on preliminary modelling results. These results highlight the potential of epidote-bearing geothermal reservoirs to facilitate CO_2 mineralization and underscore the need to evaluate how these reactions alter reservoir permeability, porosity, and mechanical properties.

Tracking tremor and drumbeat locations at Ruapehu volcano, Aotearoa New Zealand

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Ruapehu is one of the most active volcanoes in Aotearoa New Zealand, with over 100 eruptive events over the last 135 years. In 2022, the volcano underwent a significant period of unrest which included a new heating phase in the summit crater lake and strong levels of seismic tremor, the most intense observed at the volcano for nearly 30 years. The tremor was also notable for featuring a sequence of highly-periodic low frequency “drumbeats”. Both tremor and drumbeats were hypothesised to originate from within a shallow hydrothermal system but a sparse seismic network precluded accurate location information. Here we utilised the network covariance matrix approach to map the location of tremor within the Ruapehu volcanic system before and during the 2022 unrest episode. We find low level tremor was detectable up to three months before the unrest begins, beginning shortly before a small sub-summit earthquake swarm approximately 3–4 km below the summit. Tremor during the unrest period is primarily located at shallow depths, within 500 m of the summit vent, suggesting a mechanism within the shallow hydrothermal system. This study was the first to apply the network covariance method for studying tremor at Ruapehu and demonstrates the technique’s value as an effective tool for real-time volcanic tremor monitoring in Aotearoa New Zealand.

Evidence for past ‘Kaikōura-type’ multi-fault earthquakes from terrace uplift, incision, and avulsion records across the Papatea block, New Zealand

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The 2016 MW 7.8 Kaikōura earthquake in the northeastern South Island is considered a textbook example of a multi-fault earthquake (MFE) rupture. Co-seismic rupture of the sinistral reverse Papatea fault with translation of the triangular Papatea micro-block occurred with very large (up to 12 m) oblique displacements in 2016. Here we build on preliminary on-fault paleoseismic results taking an active tectonic approach to explore prior ‘Kaikōura-type’ MFE rupture cycles, applying mapping, differential lidar, soils, stratigraphy and geologic dating to understand landscape change cycles. We focus on two case studies: 1) an analysis of uplifted latest Pleistocene to recent alluvial terraces in the hangingwall of the Papatea fault; and 2) the avulsion of the lower Waiau Toa Clarence River (WTCR) and subsequent erosion on the footwall of the fault. Our results indicate that the co- and post-seismic landscape change (uplift, aggradation, avulsion, erosion) in the lower WTCR valley in 2016 has been repeated previously during the Holocene. The range of the mean recurrence intervals (RIs) of ‘Kaikōura-type’ MFEs for the Papatea fault and block is c. 2140-3630 yr, which in terms of relative timings and RI is matched by results from two other faults (The Humps, Hundalee) in the 2016 rupture sequence. In contrast, RIs for smaller paleoseismic events on the Papatea fault during the last millennia is 290-380 yr. These events are considered associated with triggered-slip from the major dextral-slip faults (Hope, Jordan thrust, and Kekerengu faults) that bound it. These ‘fast’ faults typically have RIs that are about one order of magnitude less than that for Kaikōura-type MFEs. We suggest that ‘Kaikōura-type’ MFE ruptures that displace the Papatea block by 8-12 m may occur when up-dip slip across the southernmost end of the subduction interface occurs in conjunction with rupture of many upper plate crustal faults above it.

Did a megatsunami engulf the Wairarapa coast 66 million years ago?

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The End-Cretaceous impact event at Chicxulub produced a megatsunami that reached nearly every coastline on earth within 48 hours. Despite the enormity of this event, there is very little distal evidence of this tsunami beyond the Americas. Recent modelling indicates that some of the most heavily affected distal locations would have been in the Southwestern Pacific. The Manurewa Formation in SE Wairarapa, New Zealand, spans the Late Cretaceous to the Early Paleocene and was deposited in a submarine channel that faced towards the paleo-Pacific Ocean and the impact site in the Gulf of Mexico. At several places in the formation, the Cretaceous-Paleogene (K-Pg) boundary has been identified, and contains a unique unit of high energy, disrupted conglomerate. This unit has been constrained to have formed at ~66 Ma - coincident with the K-Pg mass extinction.

This study tests whether the disrupted bed reflects a far-field tsunami deposit by addressing four major questions: A) is the deposit directly above the K-Pg boundary? B) is the deposit unique in the Manurewa Formation? C) does the deposit contain terrestrial and coastal material indicative of tsunami backwash? D) does the deposit contain sedimentary patterns and structures that can only be attributed to a tsunami? These questions are being addressed through detailed stratigraphic description, geochemical analysis to identify impact signatures, sedimentological analysis of clast provenance, shape, and size, and ichnology and dinoflagellate palaeontology to constrain depositional environment. Understanding the genesis of this deposit has significance regardless of outcome. If tsunami-related, it provides rare and novel distal evidence of the Chicxulub impact and verifies models of tsunami propagation and paleogeography. If not tsunami-related, the deposit represents a significant event in a passive margin setting, giving insights into continental shelf dynamics and regional tectonics during Zealandia’s history.

Landslide risk assessment affecting council infrastructure operation and redevelopment

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Landslide hazards present a significant challenge for the ongoing operation, maintenance, and redevelopment of critical council infrastructure, particularly where assets are located within landslide prone geological conditions and terrain.

This paper presents a landslide risk assessment undertaken for a Wastewater Treatment Plant, being a key public asset within the Coromandel region. Extreme rainfall in January 2026 triggered multiple slope failures above the facility triggering an emergency geotechnical response to assess level of risk and implement immediate mitigation and monitoring measures. Geotechnical assessment identified multiple recent landslide events triggered by heavy rainfall events at the toe of a previously unrecognised large-scale relict translational landslide more than 100 m long affecting an entire 40 m high hillslope.

A comprehensive geotechnical investigation comprising machine boreholes, test pitting, hand auger drilling was completed to develop a ground model and enable qualitative slope stability analysis. Results indicated the existing slope was only marginally stable under normal conditions (FoS ≈ 1.0) and highly susceptible to further failure during periods of elevated groundwater associated with heavy rainfall. Modelling demonstrated that reactivation of the relic landslide could inundate wastewater treatment ponds, disrupt operations, damage critical infrastructure, and potentially create off-site impacts extending beyond the facility boundary.

A risk-based assessment of mitigation options was undertaken, including monitoring, subsoil drainage, rock-fill toe buttressing, and palisade wall stabilisation. While monitoring and drainage measures may reduce the likelihood of future failures, engineered stabilisation measures such as rock-fill toe buttress or in-ground (palisade) retaining wall provided the most robust reduction in long-term risk.

The study demonstrates the importance of integrating geotechnical investigation, quantitative hazard assessment, consequence evaluation, and infrastructure risk management to support evidence-based decision making for council asset operation, resilience planning for future redevelopment and consideration of off-site (down-stream) effects in landslide-prone environments.

The new geology of the Taupō Volcanic Zone 1:130,000 map and bulletin

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This map comprises two large sheets, a digital database and associated bulletin, and is now in publication. It is the first time the diverse volcanic deposits of the entire Taupō Volcanic Zone (TVZ) have been mapped at one detailed consistent scale and utilises many technological and analytical results from advances over the last two decades. It incorporates the existing mapping and stratigraphic systems of QMAP Rotorua and adjacent sheets at a higher resolution and accuracy and is integrated with a generalised version of the 2017 Geology of Tongariro National Park map.

All of the linework, from Ohakune to Whakaari, has been redrawn for a 1:130,000 print scale, onscreen digitized utilising overlays of aerial photography and (most-significantly) nearly total coverage by LiDAR imagery. This digitising was completed at a 1:20,000 scale, generalised for readability at the final print scale, but with an accuracy to match topography that remains generally effective when viewed at a substantially higher resolution (e.g. within the digital dataset). The map incorporates and rationalises the mapping and stratigraphy of hundreds of theses, field maps, bulletins and journal publications, including substantial new dating and petrological interpretation over 20 years.

The bulletin is published in high-quality full colour and is illustrated with photographs and diagrams explaining the history and geology of the TVZ. The bulletin also includes a chronological narrative of the evolution of the TVZ, as well as sections giving an overview of the resources and hazards in the map area. It is extensively referenced to provide a comprehensive link to the primary source material for map units and analyses connecting them to their emplacement and correlation. The compilers hope that this work will be a source on which the next generation of studies of TVZ volcanism can build.

Estimating terrestrial organic carbon lateral transport and consumption using radiocarbon in DIC

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Globally, fjords are considered “hotspots” for carbon sequestration: their steep, glacially carved terrain and high rainfall deliver exceptionally large quantities of organic matter to fjords per unit area. New Zealand’s Fiordland region has some of the highest organic carbon (OC) burial rates in the world, driven in part by extreme rainfall (7–10 m yr^{-1}), landslides, and earthquakes. Sediment records and atmospheric inversions demonstrate the importance of Fiordland as a regional carbon sink; yet the fate of this carbon within the fjord system remains poorly constrained. We assess the lateral transport and transformation of terrestrial organic carbon from fjord head to mouth in Patea/Doubtful Sound and Tamatea/Dusky Sound between May 2024 and May 2025 using radiocarbon measurements of dissolved inorganic carbon (DIC $\Delta^{14}C$). Surface DIC $\Delta^{14}C$ gradients reveal expected trends such as gradual mixing with marine subsurface water toward the sea, but also significant radiocarbon depletion in 2025 relative to 2024, and a relationship between lower $\Delta^{14}C$ and lower dissolved oxygen in select isolated coves. We use a mass-balance approach to estimate the contribution of terrestrial organic carbon remineralisation to the DIC pool, and consider the magnitude of this consumption relative to terrestrial carbon inputs and deposition to sediment.

Transfer efficiency of organic carbon in marine sediments of the Hauraki Gulf

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Marine sediments represent a globally important long-term organic carbon (OC) reservoir playing a vital role in the global carbon cycle and climate regulation. Here, we quantify OC transfer efficiency in the sediments of the Hauraki Gulf, New Zealand, using a process-driven model (OMEN-SED). Transfer efficiency is defined as the percentage of the OC flux entering at the sediment water interface (FSWI) that is transferred to 100 cm sediment depth. We applied OMEN-SED to 235 sediment sites across the Hauraki Gulf using derived and observed sediment properties as model inputs. Model performance was evaluated using observations from 46 sediment sites. Sensitivity analyses investigated responses to changes in sedimentation rate, bioturbation coefficient and other model parameters. We found that transfer efficiency was low and declined with increasing sediment depth (100 cm) and burial age (0.1 ka); because sedimentation rate varies across sites, the two metrics diverge spatially despite reflecting the same degradation process, indicating that most OC degradation occurs early and close to the sediment water interface. Only 1–2% of deposited OC was transferred to 100 cm sediment-depth horizon (Teff, depth) and 0.1ka burial-age horizon (Teff, age). Sedimentation rate was the dominant control on transfer efficiency, while bioturbation coefficient (Db), estimated from water depth due to limited observational constraints, playing a secondary and opposing role. Total burial flux was primarily controlled by porosity, sedimentation rate, and initial OC content. Model performance was moderate overall and captured spatial variability across Hauraki Gulf, with TOC underestimated in the inner Gulf, reflecting terrestrial OC inputs and variable sedimentation rates, while performance was better in the central and outer Gulf. These results provide a spatially resolved assessment of OC transfer efficiency and highlight key sedimentological controls on coastal organic carbon storage in the Hauraki Gulf.

Integrating mātauranga Māori, ethnography, and geoscience to identify sources and functions of stone tools including toki (adzes): a case study from Ōtorohanga Museum

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We used a collaborative, interdisciplinary approach to document and commemorate the Ōtorohanga Museum stone-tool collection. In 2025 and 2026, we examined stone-tool artefacts, including many toki (adzes), to determine their lithology, provenance, and pre-European functionality. Our team comprises practitioners of geology, anthropology, Māori material culture, and museum curation. Using physical properties (including mineralogy observable via a hand lens), we petrographically identified 118 taonga (artefacts) with the following lithologies: basalt (19 artefacts), basaltic andesite or andesite (10), obsidian (1), pumice (1), argillite (25), greywacke (55), sandstone (2), chert (2), and nephrite/pounamu (3). The volcanic artefacts comprise 26%, sedimentary 71%, and pounamu 3% of the collection. Based on published work and oral tradition, we suggested various sources including the following: basalt (karā), basaltic andesite/andesite (makā) materials are derived from localities on Mounts Pirongia and Karioi, Ōkete Volcanics (Whaīngaroa-Raglan), Tahanga Basalt (Opita Bay), and possibly central TVZ; argillite (pakohe) from Rangitoto ki te Tonga/D'Urville Island; greywacke (ōnewa) from various sources including Motutapu Island, Hamilton Basin, Rangitoto Range, Te Tai Tokerau, west coast North Island; sandstone (hōanga) from Te Kūiti Group; chert (kiripaka) from Whaīngaroa-Raglan area and Kawau Island; obsidian (matā tūhua) from Poihipi; pumice (pungapunga) from local area; and pounamu from South Island. The taonga would have been used mainly as adzes (toki) and chisels (whao) of various types, hammerstones (kuru kowhatu), stone pounders (patu muka) or mallets (tā kowhatu), and drill bits. Our integrative work contributes to the ongoing activation and enrichment of the Ōtorohanga Museum collection, supporting efforts to uphold the mana and mauri of the taonga. The data generated help guide decisions for appropriate care, storage, and display of these taonga in ways that respect and enhance their cultural significance to mana whenua, their ties through whakapapa, and historic events associated with where the adzes were found or originated.

A revised calendar date for the rhyolitic Kaharoa eruption, Mt Tarawera, North Island, New Zealand

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The early 14th century Kaharoa eruption of the Tarawera Volcanic Complex (Okataina Volcanic Centre) is the most recent and largest rhyolitic New Zealand (NZ) eruption volumetrically (5 km³ as loose material) of the last millennium. The associated Kaharoa tephra has distinctive physical and mineralogical properties, and geochemically unique glass shards and titanomagnetite crystals, enabling it to be correlated >400 km from source over much of eastern North Island and offshore Bay of Plenty, and as a cryptotephra in lakes and bogs in the Waikato and Auckland regions.

Consequently, the tephra provides a key marker bed in late Holocene stratigraphy and archaeology and constrains the timing of early Polynesian settlement in northern NZ as an approximate 'settlement datum' (a terminus post quem). The eruption was dated by Hogg et al. 2003 (Antiquity 77, 116-125) to the austral winter of 1314 ± 12 CE (2σ) using wiggle-matching of five consecutive radiocarbon ages from carbonised wood (Phyllocladus spp.) obtained from within Kaharoa pyroclastic flow and surge deposits at the Crater Road hypostratotype section, near Mt Tarawera, against a South-Island-derived silver pine calibration dataset. However, using a new higher resolution northern North-Island-derived kauri radiocarbon dataset, a more accurate and precise calendar date of 1303 ± 8 CE (2σ) is obtained for the eruption and associated tephra deposit. Note that this date is provisional because an "official" date requires use of internationally ratified calibration curves. An update of the Southern Hemisphere calibration curve, currently SHCal20, is expected within one year and a new official date can then be obtained. An important implication for NZ's late Holocene environmental history is that deforestation signals inferred to occur a few decades before the c. 1303 CE Kaharoa eruption now more closely match Bayesian-modelled radiocarbon dates for initial Polynesian settlement (1250–1275 CE) of North Island.

Mapping the Green Island Fault: A marine seismic investigation of offshore faulting near Dunedin

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The slow-slip rate faults of the Otago Range and Basin region pose a challenge for understanding regional earthquake hazards because of their long recurrence intervals and the short historical record. Paleoseismic and land-based geophysical studies provide a longer record of fault activity, indicating that the region's northeast-striking, subparallel reverse faults are capable of generating large earthquakes (Mw > 7). Paleoseismic studies have identified three ground-rupturing earthquakes on the Akatore Fault within the past 15,000 years, including two within the past 1,200 years, making it the most active fault in the region. This study extends these characterisation efforts offshore by integrating high-resolution multichannel marine seismic data collected during surveys between 2009 and 2026 to constrain the location and activity of the Green Island Fault in relation to the Akatore Fault. It remains uncertain whether the Green Island Fault is a separate, inactive Neogene-age structure or is connected to the active Akatore Fault and could rupture as part of the same system.

We bring together the results of the marine seismic surveys to produce a unified interpretation of the offshore faults north of the onshore extent of the Akatore Fault at the Taieri River mouth. Selected surveys of the dataset have been reprocessed to reduce the effect of ocean swell in the seismic profiles. The seismic dataset will be used to refine the geometry, activity, and extent of the Green Island Fault and evaluate interpretations of the evolution of the offshore fault system. If connected, this determination would extend the recognised active fault system northeastward and closer to Dunedin, bringing the associated hazards closer to the city. Our findings will determine whether the Green Island Fault is active, and potentially provide input to earthquake source models.

Rumbling and puffing: linking volcanic tremor and SO_2 degassing at Whakaari/White Island

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Volcanic tremor and SO_2 emissions are widely used to monitor volcanic unrest, as they can reflect changes in magmatic fluid movement. Correlations between the two have been observed at several volcanoes, but their strength and consistency vary through time and between volcanic systems. This variability may reflect changes in processes affecting fluid flow, such as magmatic fluid supply, sealing, cracking, and interactions with the hydrothermal system and lake. For instance, at volcanoes with crater lakes like Whakaari, interactions between hydrothermal and magmatic fluids can remove SO_2 from the gas phase and form sulphate mineral seals, reducing permeability and potentially decoupling SO_2 emissions from tremor. At Whakaari, periods of elevated SO_2 emissions generally correspond with increased tremor over multi-year timescales. However, it remains unclear whether a systematic relationship exists, whether this is consistent at different timescales, and whether it varies with the degree of unrest. Here, we use real-time seismic amplitude measurement (RSAM) and differential optical absorption spectroscopy (DOAS) measurements spanning 2009-2021 to investigate the relationship between tremor and SO_2, and its temporal variability. Preliminary results show a weak correlation between individual measurements ($r = 0.27$), reflecting high intra-day variability in SO_2 measurements relative to RSAM. We therefore apply a cumulative sum (CUSUM) analysis which, standardised to baseline tremor and SO_2 emissions, shows systematic and concurrent departures from background over multi-year timescales, coinciding with known periods of volcanic unrest. However, within individual periods of quiescence and unrest, CUSUwith baselines standardised to that period reveal variability in the coupling between RSAM and SO_2, with increases in one parameter not necessarily accompanied by increases in the other. We then use these relationships to discuss processes at the volcano and link them to visual observations.

Te Tūkohu Ngāwhā: the evolution of a mātauranga-based science fair

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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

Volcanic lakes of Ahi Tupua

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The Volcanic Lakes of Ahi Tupua offer deep blue windows into a storied history of Volcanic Life. They are connected to one another through magmatic, hydrologic, and ancestral pathways; yet each is a unique entity. Ahi Tupua represents an ancestral fire that fuels more than geothermal heat and energy; it is the essence of the earth that lends its name to the land. To understand the role of Ahi Tupua as more than resource or land, we apply the lens of Geologic Life.

This talk will reflect on three years of PhD research, in collaboration with iwi and science partners, investigating the dynamics of the volcano-limnic systems across the region. We have combined geochemical techniques with environmental monitoring to develop novel approaches to holistic research.

Across the lakes we have conducted surveys of temperature, pH, and dissolved CO_2, collected and analysed gases emitted from subaqueous vents, examined never-before-seen submerged volcanic features, and worked with community groups to be better prepared for local limnic and volcanic hazards.

In this talk we will demonstrate a contemporary understanding of Ahi Tupua's Volcanic Lakes informed by recent data collection endeavours, ongoing Mātauranga Māori, and a recontextualization of previous research.

Investigating the role of magmatic volatiles in magma-borehole encounters at Krafla and Námafjall, Iceland

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Krafla volcano in north-eastern Iceland offers a unique natural laboratory for studying magma-hydrothermal interactions, highlighted by recent instances of geothermal drilling penetrating shallow silicic melt (e.g., borehole IDDP-1 in 2009). However, a lesser-known encounter with magma in a geothermal well occurred in 1979, partway through the 1975-1984 Krafla Fires volcanotectonic episode, when primitive basaltic glass (~7.3 wt.% MgO) was retrieved during cleaning of a blockage in borehole KJ-9. This composition is unusually primitive for intra-caldera material and suggests that the magma involved in the Krafla Fires may have been derived from the magma encountered here. This event contrasts with a 1977 eruption from borehole 4 at the nearby Námafjall Geothermal Field, producing glassy scoria with ~5.2 wt.% MgO. The scoria produced by this eruption is geochemically distinct from an eruption earlier on the same day, but similar to other eruptions throughout the Krafla Fires. These events raise the question of why the injection of magma triggered an eruption in one borehole but passive quenching in another. This study quantifies volatile concentrations and speciation in the KJ-9 and borehole 4 glasses to reconstruct syn-encounter magmatic processes. Initial conventional Fourier-transform infrared (FTIR) spectroscopy of the KJ-9 glass reveals low total H_2O contents (~0.2 wt.%) and an absence of detectable molecular H_2O, indicating magma degassing prior to entering the bottom of KJ-9. This pre-encounter volatile loss drastically reduced the magmatic internal pressure, likely preventing fragmentation and subsequent eruption from KJ-9. The borehole 4 glasses have somewhat higher total water contents (~0.5 wt.%), likely contributing to the eruption. To resolve the precise timescales and mechanics of this behaviour, high-spatial-resolution synchrotron FTIR analysis will be used. This technique will target diffusion gradients at sample edges and in vesicular domains to contrast volatile behaviour during the passive KJ-9 quench with the more explosive borehole 4 eruption.

The Sloggett Canyon, a major pathway for offshore export of terrigenous sediments across the continental margin of southern Patagonia

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The continental margin south of Tierra del Fuego (Argentina) is characterized by a narrow continental shelf and a well-developed system of submarine canyons. Among these, the Sloggett Canyon stands out because of its dramatic incision and the proximity of its head to the coastline and the Lopez river mouth. Historical hydrographic and bio-optical data, together with global ocean physics reanalysis (GLORYS12V1) outputs, were used to investigate dynamical processes around the canyon. Pumping of intermediate waters into the euphotic layer, accompanied by enhanced chlorophyll-a fluorescence, was observed in the upper reaches of the canyon. In addition, an instrumented mooring line was deployed for one year in the main canyon axis at 1940 m depth. This mooring consisted of an ensemble of a current-meter, a turbidity logger, a sequential sediment trap and a SBE-37 CTD replicated at 20 and 200 metres above bottom. The results indicated that pronounced upwelling and downwelling cells develop as the impinging slope current (the northernmost branch of the Antarctic Circumpolar Current) interacts with the canyon morphology, with episodes of northern winds reinforcing the upwelling. Suspended-sediment transport in the middle canyon, at the mooring site, was directed down-canyon and was dominated by short-lived pulses reaching up to 3 g m-2 s^{-1}. Downward mass fluxes measured by sediment traps ranged from 5 to 39 g m^{-2} d^{-1}, whereas organic-matter fluxes ranged from 31 to 600 mg m^{-2} d^{-1}. Near-bottom fluxes of particulate matter reaching the mooring site tended to be higher in coincidence with the spring freshet, suggesting a likely connection between the middle canyon and riverine terrestrial sources, presumably via density currents or hyperpycnal flows. Our results identify the Sloggett Canyon as both a hotspot of biological productivity and a significant offshore trap and conduit for terrigenous particulate matter and carbon from the continental shelf towards deeper ocean.

The Rewa River–Suva Canyon–Kadavu Passage sedimentary system (Fiji): implications for geo-hazards and carbon sequestration

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Viti Levu, Fiji's largest island, has a humid climate, with high annual precipitation concentrated on its windward side. Consequently, powerful rivers drain relatively small catchments and exhibit flash-flood regimes. Ubiquitous reef barriers fringe the coast, forming lagoons that buffer riverine sediment inputs while supporting rich ecosystems and accommodating urban estuaries. Earthquakes, cyclones, landslides, volcanic eruptions and tsunamis, all well documented in the region, can remobilize sediment temporarily stored in these coastal lagoons and transfer it offshore in high-energy pulses. These events contribute to sculpting and maintaining a well-developed network of submarine canyons, and may also pose hazards to coastal populations, infrastructure and submarine communications cables.

Among these active pathways exporting terrestrially-derived material to the open ocean, the Rewa River–Suva Canyon–Kadavu Passage (RSK) system is selected as an exemplary case study. It represents a promising climatic and volcanic archive, as well as a natural laboratory for investigating the gravitational processes that connect volcanic islands to deep-sea depocentres. This contribution reviews the current state-of-knowledge of the RSK sedimentary system and outlines a concept for advancing its understanding. Particular attention is given to the relevance of these multi-stage sediment-transfer processes for carbon sequestration.

Modeling stress and deformation near intersecting misoriented normal faults in the Taupō Rift, Te Ahi Tupua: a new approach to target geothermal permeability?

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Intersecting normal faults that depart from ideal Andersonian orientations in a rapidly extending rift, subject to both orthogonal and rotational opening as well as magmatic activity, generate complex patterns of stress interaction. We investigate these processes in the Wairākei Geothermal Field, the oldest and largest electricity producer within the Taupō Rift, Te Ahi Tupua. There, boreholes show pervasive fracturing both near and away from faults. We developed three-dimensional forward finite element models (FEM) with the Adeli open-source code which accounts for elasto-visco-plastic behaviour (pressure dependent Drucker-Prager plasticity and temperature dependent viscosity). We simulate far-field extension applied on a simplified crustal scale, synthetic fault system consistent with the structural settings. Three steeply dipping (70°) pre-existing faults are set mechanically weaker than the surrounding bedrock. One fault has Andersonian strike, while two intersecting faults are misoriented by –15° and +30°.

Modeled fault displacements and stress rotations broadly agree with paleoseismic slip rates and with the limited but clear stress rotations observed in geothermal boreholes. Preliminary results provide indicators to explain enhanced crustal permeability: zones of strain localisation where fracturing concentrates; stress ratio reflecting how faults behave kinematically with respect to the applied regional stress field; domains undergoing stress rotations and creating conditions where fractures of various orientations become optimally oriented for slip and dilation, most pronounced in domains within 1-3 km of the pre-existing faults.

Alternating boundary conditions between orthogonal and oblique rift extension (representing rotational rift opening or nearby magma deflation) further enhances the opening of fractures of different orientations at different times. We also tested the influence of the main faults dip and relative strength.

This approach provides new insights into stress evolution in magmatic rifts, with implications for seismic and volcanic hazard assessment and for improving the targeting of permeable zones in geothermal reservoirs.

Creating a geological database for community benefit, Gisborne-Tairawhiti

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A geological compilation and revision of the Waimata and Taruheru catchments, including Gisborne City has been undertaken for the purpose of community benefit and to satisfy the author's curiousity. The exercise has taken advantage of open-source technology and open-data imagery such as LiDAR, aerial and satellite images to allow creation of basemaps at resolutions not previously possible.

The exercise included capture of observations from existing published papers and reports and locally significant catalogues and public databases such as historical geological maps/fieldsheets and fossil and drilling records. Adjustments and corrections to the location and other attributes from these records was necessary to match their descriptions and the adopted basemap. While many structural measurements were captured, there is a paucity of lithological descriptions available, and where possible the latter were added to a sites database.

A thematic mapping approach was undertaken using topology rules where for instance bedrock and Quaternary polygons are placed in seperate layers so that they are not mutually exclusive; removing the compromise of traditional mapping approaches. This approach also provides significant advantages for landscape modelling. Geomorphic mapping was an important exercise, creating seperate themes for landslides and other morphological features but also to adjust previously mapped geological features where they have morphological expression in the landscape.

The burgeoning availability of geological tools available in open-source GIS software provides methods for improved geological mapping techniques, analysis, automation and presentation. These factors along with affordable consumer-grade computing hardware requirements, widens the opportunities for those outside of major institutions.

The provision of open-data format spatial datasets provides powerful and accessible information tools for communities. Factual data and interpretation must be clearly distinguished as a basis for defendable landuse decisions and to assist future additions and revisions. It is also hoped this approach provides an example of where geological mapping could evolve.

A geological concept map of the Waimata Catchment and surrounds, Tairawhiti/Gisborne.

Colin Mazengarb[1]
[1]Retired Private Researcher, Hobart, Australia

This map is a representation of a geological database and interpretation compiled by the author largely from public data sources as a desktop exercise with limited field checking. The compilation was undertaken to trial contemporary geospatial methods of data collection and to satisfy the author's geological curiosity. The availability of powerful open-source software (QGIS, WebODM, IrfanView, etc.), the open-data policy of the NZ Government and standard home computer hardware has allowed me to do this at minimal cost.

The mapping philosophy has its roots in the national QMAP 1:250 000 series but with some notable changes:

1) Topology: Quaternary and bedrock polygon units are mapped as separate layers, eliminating mapping conflicts where overlap occurs. Bedrock polygons are extended beneath covering units where reasonably certain; otherwise, they are left blank. Geomorphology features are divided into natural and artificial themes.
2) Data-centric: A database-centric approach is adopted while cartographic aspects are automated as much as possible. A sites database provides a point record of outcrop observations (lithology, etc.) beyond the standard structural measurements.
3) Data corrections: Adjustments to contributing databases such as the Fossil Record (FRED) have been necessary to correct obvious location and attribute errors, by comparing records against original maps and descriptions. Additional collections included in petroleum reports have been added to my local copy.
4) Heads-up data entry: Data entry (particularly digitising) is performed directly in GIS format rather than on intermediate compilation sheets. Predefined styling allows the map to be correctly visualised as digitising proceeds and allows mistakes to be corrected early.
5) Mapping tools: A number of geological mapping tools are available as QGIS plugins that allows improvements in mapping accuracy and analysis.
6) Legend automation. QGIS provides tools for automating legend construction, where legends contract or expand as map extents (and its contents) change.

Autonomous CO_2 flux mapping on volcanic lakes using a robotic boat

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Volcanic and geothermal lakes are critical surface expressions of underlying magmatic–hydrothermal systems. Quantifying CO_2 degassing across these water bodies provides baseline insights into sub-lacustrine vent dynamics and volcanic unrest. However, traditional manual boat surveys using floating accumulation chambers are constrained by coarse spatial resolution, logistical complexity, and acute health and safety hazards for personnel operating on hyperacidic, gas-rich waters.

To address these challenges, we developed and field-tested "FluxBoat," a customized Autonomous Surface Vehicle (ASV) engineered for high-resolution lacustrine CO_2 flux mapping. The platform features a twin-pontoon catamaran frame, corrosion-resistant subaerial air-fan propulsion, dual-GNSS navigation, and an automated servo-lift floating accumulation chamber paired with an onboard NDIR gas analyser. This architecture enables fully automated cycles of transit, ambient-air purging, surface landing, and flux measurement without disturbing the delicate water–air boundary layer.

Proof-of-concept deployments were conducted across acidic Lake Rotokawa (pH ~ 2) across four campaigns between 2023 and 2026. Despite operational constraints from wind-driven wave chop, the vessel successfully surveyed 108,017 m^2 and acquired 85 high-quality measurements. Recorded CO_2 fluxes ranged from 12.84 to 899.51 $g/m^2/day$ (mean 195.25 ± 160.97 $g/m^2/day$), capturing diffuse background degassing alongside intense sub-lacustrine vents. Spatial mapping via Sequential Gaussian Simulation (sGs) and comparison with regional geothermal soil degassing baselines confirms that the lake acts as a focused discharge structure. This study demonstrates the viability, durability, and safety of autonomous surface platforms for routine volcanic monitoring and hazard response across New Zealand.

Compounding rainfall-triggered sediment hazards from hillslope to floodplain

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Coupled geomorphic system responses can compound source-to-sink sediment hazards. Whether connectivity pathways are effectively engaged and compound at catchment scales during a single forcing event (e.g. storm) is relatively unexplored. We tested this idea with the February 2023 Cyclone Gabrielle flooding in the Esk catchment, Hawke's Bay.

We used pre- and post-event lidar, imagery, and hydrological data to analyse the Esk catchment response. Using DEM-based analysis of geomorphic change, we measured patterns of erosion and deposition and used a reconstructed flood hydrograph to estimate likely sediment concentrations. The changes were apportioned into three process domains: hillslope, valley widening, and fluvial. Within the hillslope domain we manually mapped landslides and quantified sediment delivery volumes, to isolate this from non-landslide contributions.

We mapped >27,000 landslides, which stripped ~3.5 million m³ of debris from their source areas, and eroded a further ~2.5 million m³ along their runout paths. Almost half (~3 M m³) of the landslide debris entered the river network. The DEM-based analysis suggests the hillslope domain possibly generated and delivered an additional ~4 and ~2 million m³ respectively, from non-landslide processes (e.g. rilling & sheetwash). In the valley widening domain, river-induced landsliding and scour eroded ~6 million m³, with half exported to the river. The fluvial domain experienced ~4.5 million m³ of erosion and ~5 million m³ of deposition. The resulting Esk River flows had median sediment concentrations of 9-15% by volume, above typical thresholds for hyperconcentrated flow. Almost 8 million m³ of sediment was exported from the catchment (i.e. delivered to the ocean).

We suggest the high intensity of channel-coupled landslides initiated a chain of erosion by sediment-laden flows. This in turn, likely facilitated valley widening by further landsliding. The Esk catchment was a highly coupled geomorphic system which likely compounded the downstream flood impacts in this event.

Remote acoustic and lightning observations capture the inundation and descent of the Hunga vent on 13–14 January 2022

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The December 2021–January 2022 eruption of Hunga volcano, Kingdom of Tonga, was stunning in part because of its climactic end, which generated a 58 km-high plume, a globally detected Lamb wave, record lightning rates, and devastating tsunamis. Many studies have examined the 15 January event, but few have investigated the activity before the final day. Satellite images document island growth from eruptive deposits with a vent open to the atmosphere on 2 and 6 January. Then, late on 14 January, after what was arguably the largest eruption observed since Pinatubo, only to be outdone the next day, the Planet image shows ocean water where the vent was, dividing the original island. We use remote infrasound, lightning, and hydroacoustic data to examine the 13–14 January eruption sequence for evidence and timing of vent flooding. We source acoustic data from the International Monitoring System infrasound array IS22 (~1800 km due west) and hydroacoustic array H03 (~9,300 km east). Near-continuous, broadband infrasound detections start at ~15:17 UTC on 13 January, followed ten minutes later by lightning. At ~17:15 UTC, the infrasound amplitude increases and the frequency content changes to predominantly low frequency (0.05 to 0.1 Hz). These changes remain for the duration of this episode and suggest a source change, such as decreased flux, increased vent diameter, or crater flooding. About 15 minutes later, the lightning rate decreases from 300–500 to 100–200 flashes per minute, which could reflect a flux decrease or changes in plume properties. Inundating the vent with ocean water could filter out higher infrasound frequencies and change hydrostatic pressure in the conduit, reducing flux into the atmosphere and lowering the lightning rate. Hydroacoustic signals are not detected until ~10:00 UTC on 14 January. The delayed hydroacoustic detection may be due to crater bathymetry, vent depth, or signal strength.

Vent-scale mapping of the Okete Volcanic Formation in Whāingaroa (Raglan) Harbour

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Whāingaroa Harbour preserves lava flows, tuffs, scoria deposits, and dikes of the 2.6–1.9 Ma Okete Volcanic Formation, among the earliest evidence of alkaline monogenetic volcanism in the Auckland Province. The harbour has been mapped at 1:25,000 scale to place its vents within the tectonomagmatic evolution of the Alexandra Volcanic Group. Land- and canoe-based field mapping was integrated with lidar-derived geomorphology, aeromagnetic data, drill-core logs, petrography, whole-rock geochemistry, and $^{40}Ar/^{39}Ar$ geochronology to define and correlate map units.

Mapping identifies six basaltic volcanic centres in the harbour area, including a previously unrecognised scoria-cone complex on the northern shore and several previously unrecorded dikes in the intertidal zone. The mapped Okete centres comprise lava flows, scoria cones, tuff rings, and truncated feeder dikes, whereas Karioi-derived ring-plain deposits and at least one lava flow are intercalated with Okete products in the lower harbour. The succession records predominantly subaerial volcanism interrupted by groundwater-driven hydrovolcanic eruptions, represented by tuff-ring deposits and hyaloclastitic domains within some lava flows. Several flows exceed 30 m in thickness and appear to have ponded in palaeovalleys within the dendritic harbour catchment.

These results refine the distribution of vents along the Alexandra Volcanic Lineament and support its interpretation as a record of the onset of alkaline volcanism during rollback of the Pacific slab at ca. 3–2.5 Ma.

Mapping the offshore volcanic landscape of the Auckland Province

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The Auckland Province comprises age-progressive basaltic monogenetic volcanism distributed along the west coast between Raglan and Auckland. Its four volcanic fields (Okete, Ngatutura, South Auckland, and Auckland) are extensively mapped onshore, but stratigraphic relationships and local mātauranga-a-hapū indicate that the Okete and Ngatutura volcanic fields extend offshore onto the continental shelf. We integrate reef maps, regional aeromagnetic data, and two-dimensional seismic-reflection profiles to map the shelf between Albatross Point (Kāwhia) and Port Waikato to define the offshore extent of the Okete Volcanics (2.6-1.9 Ma) and Ngatutura Volcanics (1.8-1.5 Ma).

Around 70 previously unrecognized volcanic centres are identified on the western shelf, including scoria-cone and lava-field complexes as well as tuff-ring-diatreme systems. Fifty-one centres extend the Okete Volcanics up to 25 km west and southwest of Karioi across approximately 500 km² of continental shelf, increasing the mapped area of the Alexandra Volcanic Group by 45%. A further 21 centres enlarge the mapped extent of the Ngatutura Volcanic Field by approximately 130%, adding around 300 km² to its known distribution.

The new mapping increases the known volcanic footprint of the Auckland Province by 25% and identifies three temporally distinct northwest-stepping eruptive domains. These domains trend NW-SE, parallel to the Alexandra Volcanic Lineament, suggesting that a common structural control persisted throughout 2.6 million years of volcanism. Their progressive northwestward migration is consistent with tectonic forcing linked to rollback of the Hikurangi subduction zone. These results demonstrate how integrated geological, geophysical, oceanographic, and mātauranga Māori evidence can reveal volcanic landscapes concealed beyond the modern coastline and guide future bathymetric, geological, and habitat investigations.

Preliminary findings from field-based investigations of the surface rupturing 2026 Amata earthquake, central Australia.

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In 2026 Australia experienced its 12th surface rupturing earthquake since 1968. The earthquake occurred at 18:26 UTC on 4 April 2026 with a moment magnitude (Mw) of 5.5. The hypocentral depth is poorly constrained but is likely less than 4 km based on surface deformation and fault parameters. The earthquake was located approximately 74 kilometres southwest of Uluru, Northern Territory. Researchers undertook remote sensing and field-based investigation in the days and weeks after the event, documenting a ~10 km long surface rupture with a maximum vertical surface displacement of 1.1 m.

We present the preliminary findings from the remote sensing and field-based investigation including InSAR, surface rupture mapping derived from field and drone observations, near-rupture digital elevation models and a macroseismic shaking intensity map. We find this event resulted in minimal environmental damage (e.g. cracking, vegetation damage, rockfalls) compared to some other historic Australian surface rupturing earthquakes, which we attribute to only moderate shaking intensity from this Mw 5.5 earthquake and low landscape fragility. However, we expect over geological timescales that the permanent landscape change resulting from instantaneous hanging-wall uplift will have significant effects on local drainage and dune morphology in this otherwise geomorphically stable region. We find consistency between the Amata earthquake and the twelve other historic Australian surface rupturing earthquakes in terms of bedrock structural inheritance control of the rupture, no evidence of previous neotectonic faulting, and a very shallow hypocentral depth.

Imaging Ōkataina volcano, Aotearoa New Zealand, with newly collected dense nodal seismic data

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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 initial results from ambient seismic noise interferometry seeking to improve 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. We use newly collected data from the high-density Makatiti and Haroharo Nodal Array (MAHANA) installed October 2025 to March 2026 in partnership with local Iwi Trusts (92 short-period seismic nodes with a 1–2 km station spacing in the main part of the network). The imaging results from the ambient noise analysis will help 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.

When an isochronous tephra is not: the case of the Potaka tephra

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The term Potaka tephra was introduced by Shane (1994: NZ J Geol Geophys 37, 25) to encompass fall deposits and a widespread ignimbrite plus reworked deposits from a major eruption around 1 Ma. The ignimbrite and fall deposits were grouped as products of the Kidnappers eruption from Mangakino volcanic centre by Wilson et al. (1995: Nature 378, 605). After 1-2 decades the Rocky Hill ignimbrite eruption occurred, also from Mangakino. These two events, combined here as the Kidnappers-Rocky Hill (K-RH) eruption, discharged >1,700 km^3 of rhyolitic magma across New Zealand and the southwest Pacific at ~1.01 Ma, during the Jaramillo Subchron. The K-RH deposits are widespread and, as the Potaka tephra, have long provided an important stratigraphic marker. However, the term Potaka tephra has been applied to both primary and reworked deposits, masking significant differences in their depositional histories. Here, we question the reliability of the Potaka tephra as a chronostratigraphic marker by examining its occurrence within Whanganui Basin sediments. Potaka material occurs within both normal- and reversed-polarity sediments of the Jaramillo Subchron and later, demonstrating that its stratigraphic occurrence cannot be used to define a single depositional horizon. Rather, the presence of Potaka tephra in sediments of different ages indicates that volcanic material was repeatedly remobilised and redeposited following the eruption, in particular at the time of the marked sea-level rise at the start of MIS 25. The Potaka tephra is therefore diachronous, despite its widespread adoption as a marker horizon. The implications of this extend beyond the Potaka tephra itself. These results highlight the importance of distinguishing primary and reworked tephra and avoiding blanket tephra nomenclature in chronostratigraphic studies. Failure to do so can generate false correlations, propagate erroneous ages between sedimentary sequences, and ultimately lead to incorrect reconstructions of sedimentation rates, palaeoenvironmental change and volcanic history.

Ash on ice: a ~350 ka New Zealand supereruption preserved in a deep Antarctic ice core

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Volcanic signals (sulfate anomalies, tephra layers) preserved in ice cores provide critical isochrons for ice core chronologies and allow for the assessment of eruption impacts. In Antarctic ice records, however, these signals are often sparse and become increasingly difficult to resolve at depth due to chemical diffusion of sulfate anomalies and ice thinning attenuating tephra layers. As a result, older sections of ice contain fewer clearly identifiable volcanic horizons. Here we identify and correlate a sulfate anomaly in the European Project for Ice Coring in Antarctica (EPICA) Dome C ice core to the New Zealand-sourced Whakamaru supereruption through the presence of glass shards with a unique double geochemical fingerprint and stratospheric sulfur isotopic signatures. This recognition and correlation enables three key advances. First, it refines a Whakamaru eruption age estimate to 347.5 ± 1.2 ka during glacial period Marine Isotope Stage 10, consistent with existing marine and terrestrial chronologies. Second, it provides evidence for no millennial-scale climate response, despite petrological estimates of very large stratospheric sulfate loading (>800 Tg) from this eruption. Third, it demonstrates that even in deep Antarctic ice, where volcanic sulfate peaks are broadened by diffusion, signals from the largest volcanic events can be preserved and targeted for source identification. Together, these findings highlight the potential for targeting volcanic isochrons in deep ice, particularly from Southern Hemisphere sources, providing novel age markers that should be considered even for the oldest Antarctic ice cores.

Evolution of the Auckland Volcanic Field (New Zealand) boundary

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Monogenetic volcanic fields pose a significant risk to life and infrastructure when situated near urban regions. To place constraints on developing volcanic unrest scenarios and apply hazard mitigation measures, emergency planners and decision makers must consider where the next eruption may occur and the likelihood that it will be within the present bounds of the field. Utilising a high-precision chronology of eruptions, tested against a synthetically derived dataset, we examine the likelihood that the next eruption from the Auckland Volcanic Field (AVF) will occur within or outside of the present field boundary. We mapped the spatial-temporal growth of the field using a temporally evolving convex hull boundary, and the locations of subsequent eruptions were then tracked to test whether they fell within the convex hull boundary defined by the existing eruption centres. When considering eruptions since 63 ka, this retrospective approach reveals a probability of 71% that the next eruption will fall within the current boundary of the field or 74% when age uncertainty is considered. When a 3.5 km buffer is added to the convex hull, the probability increases to 98%. Meanwhile, use of a synthetic dataset allows a forward looking analysis which suggests a 2 km buffer may be sufficient to capture at least 95% of future eruption locations. We found that the AVF boundary grew in steps, where one to four new eruptions would occur outside the boundary with subsequent eruptions within the newly expanded boundary. Local scale spatio-temporal clustering also occurs with successive clustered centres aligning in a NNE/NE direction. We propose that this process relates to either changing magmatic source processes or crustal magmatic pathways that are available for use for multiple eruptions before closing off to new magma due to conduit cooling, solidification or changing tectonic stress patterns.

Understanding the implementation pathway: integrating user feedback into the design for volcanic ash forecasting tools

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All of Aotearoa New Zealand's volcanoes can erupt explosively, producing volcanic ash that can be injected into the atmosphere, dispersed by the wind, and then settle to the ground. Ash hazard maps issued in response to eruptions show forecasts of the extent, amount of timing of ash hazard, either in terms of ground accumulation or airborne concentration. Consequently, such maps are critical tools for informing mitigation strategies and estimating impacts and loss. The reliability of ash forecasts, however, depends on knowledge of Eruption Source Parameters (ESPs), e.g., plume height, eruption duration, erupted mass, that are inputs to ash transport models. Our project seeks to develop near-real-time ESP characterisation tools to provide rapid (<30 minutes) and accurate estimates that can be continuously updated during an eruption, providing valuable input to ash dispersion and ashfall models.

Rapid ESP estimates will enable next-users (e.g. volcano observatories and Volcanic Ash Advisory Centres) to initiate ash forecast models with accurate input parameters, and issue reliable initial forecasts rapidly following eruption detection, informing advice given by next-users to their stakeholders (e.g., CDEM, infrastructure managers, aviation, community leaders). In order to ensure uptake of innovative science it is necessary to understand and account for the entire implementation pathway from data acquisition, transmission, storage and analysis through to how information is currently used, by whom and how, as well as any potential pitfalls that need to be accounted for in the future. Our intentional engagement design strategy employs participatory methods to create a collective understanding of the pathway and a collaborative effort to mapping out a roadmap for use of real-time ESP estimates in operational forecasts. The results from our user engagement are informing the development of tools to characterise explosive eruptions that can be easily incorporated into the processes and requirements for advice and next-generation ash forecasts.

Understanding Te Puia o Whakaari - bridging mātauranga Māori and western science to create integrated educational resources for tamariki

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Weaving together mātauranga Māori and geoscience integrates their strengths into community disaster and emergency preparedness resources for children and the wider community. By reflecting on mātauranga Māori as a knowledge system to be used in disaster risk reduction, and challenging what traditional 'science' looks like we can explore unique ways to integrate disaster preparedness into everyday life. Māori researchers are uniquely positioned to bridge the gap between mātauranga Māori and science to translate this knowledge to the community. Local iwi knowledge coupled with western learning allows the strengthening of scientific research by bringing humanity and community to the forefront.

Here we weave together the science around potential impacts of a Whakaari eruption or landslide, volcanic preparedness, community education and mātauranga Māori. Historical pūrākau (Māori narratives and stories) gathered from literature, alongside oral traditions from local tangata whenua or the principal tribal authority in the rohe/area have been collected to create a resource to be used in the community, at schools and shared through local events to support emergency preparedness. We combined mātauranga Māori with the science knowledge from the MBIE-funded Beneath the Waves research programme, to understand the impacts of hazards from Tūhua and Whakaari on Aotearoa. We used this combined knowledge and worked with emergency response organisations and the wider community to mitigate potential impacts. The result of weaving the pūrākau of Whakaari into community disaster preparedness communications is a children's book with accompanying learning resources for engaging learning use in the community and classroom.

Three-dimensional approach to volcanic processes: a methodology in Dragonfly (ORS)

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Pumice clasts contain vesicles that record bubble nucleation, growth, coalescence, and fragmentation processes that occurred before and during eruption. Understanding the size, shape, number density, and distribution of these vesicles is critical for reconstructing magma ascent mechanisms and eruptive histories. Traditional vesicle size distribution analyses have been confined to two-dimensional thin-section observations, which rely on assumptions regarding size and shape. This methodology is accompanied by complications arising from damage during sample cutting and processing. Micro-computed tomography (MCT) analysis is becoming an increasingly common technique in volcanology for quantifying the characteristics of volcanic materials, providing a non-destructive, three-dimensional approach for investigating rocks. However, there is currently no standardised methodology, and the software required to process and quantify these datasets is often complex and, in some cases, expensive.

This study focused on using Object Research Systems (ORS) Dragonfly 2024.1 software to develop a workflow for reconstructing and quantifying the textural characteristics of volcanic rocks. The software offers a free academic licence and is user-friendly. Using MCT images obtained at the Australian Synchrotron, we investigated two case studies comprising andesitic pumice clasts from Mt. Taranaki and silicic pumice clasts from the Central North Island of New Zealand. The aim was to develop a methodology for segmenting vesicles (voids), matrix (glass), and mafic crystals for quantifying volcanic textures.

Andesitic pumice clasts have thicker vesicle walls and small vesicles, allowing for easier vesicle segmentation. In contrast, silicic pumice clasts contain thinner vesicle walls and larger vesicles, resulting in increased image noise and therefore requiring additional filtering steps. Vesicle number densities and size distributions produced through this methodology are comparable with previous studies and provide an accessible tool that enables researchers to investigate eruptive processes.

Textural evolution of the ~232 CE Taupō eruption products

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Melt composition and volatile content control bubble nucleation and growth within a magma body, thereby influencing exsolution and outgassing. As these processes cannot be directly observed, volcanologists rely on erupted materials as a record of magma ascent. Deposits of the 232 CE Taupō eruption provide an opportunity to investigate complex bubble nucleation and growth histories for a uniform magma composition. The eruption comprised six phases that produced three phreatomagmatic ash deposits (units Y1, Y3, Y4 [with a pumice-bearing bed, Y4C, sampled for this study]), two plinian fall deposits (units Y2, Y5), and a widespread ignimbrite (unit Y6), spanning five orders of magnitude inferred discharge rates (10^5-10^{10} kg/s^{-1}). The samples acquired from these units provide an opportunity to assess how changes in shallow conduit processes influenced eruptive styles.

The Australian Synchrotron Micro-Computed Tomography beamline was used to investigate textural characteristics of pyroclasts. Pumice clasts from all units have vesicle number densities from 1.22 x 10^5-6.51 x 10^6cm^{-3}, indicating a highly connected vesicle network. Pumice vesicularities within units Y1-Y4 are predominantly 65-75vol.%, whereas vesicularities within units Y5 and Y6 are higher, indicating a highly developed foam even within the phreatomagmatic phases. Vesicle size distributions reveal contrasting ascent histories, ranging from multi-phase (Y1), single-stage nucleation events (Y2), ripening (Y3), foam collapse (Y4), and coalescence (Y5 and Y6). The main bubble populations follow a power-law trend with d-values from -2.8 to -6.4, indicating non-steady-state nucleation and growth throughout the sequence. Mid- to late-stage bubble coalescence indicates early-onset nucleation and the development of a connected foam throughout the eruptive sequence, while variations in shallow conduit processes promoted variable, secondary, late-stage nucleation. Units Y3 and Y4 display evidence of pre-eruptive degassing, suggesting temporary storage within the conduit prior to eruption. Our results further highlight the complexities of shallow conduit processes in the 232 CE Taupō eruption.

Using a targeted seismic array and machine learning to illuminate the Marlborough Fault System's deep structure

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Aotearoa New Zealand's Transition Zone covers the northern part of the Alpine Fault, the Marlborough Fault System, the North Island Dextral Fault Belt and the southern part of the Hikurangi Subduction Zone. This region marks the transition from a subduction-dominated environment to a transpressional regime. The Marlborough Fault System was the location of the complex M7.8 2016 Kaikōura earthquake, which ruptured at least 21 distinct faults. How faults within the Transition Zone connect to adjacent sections of the plate boundary is an active area of research, as it likely influences the scale of earthquake ruptures in this region, as well as the potential for earthquake cascades.

Here, we present initial results from data collected by the 47-station Marlborough Observatory Researching Interconnectedness beneath the Alps (MORIA) broadband array, together with the associated Disaster Prevention Research Institute and GeoNet networks (with 23 and 79 stations, respectively). Using machine learning for phase detection and association, we identified 41,866 events between 1 January 2024 and 30 September 2025. This represents an increase of approximately 158% compared with the 15,524 events reported by GeoNet in the same period. In addition, we used a machine learning polarity picker to compute first-arrival polarity focal mechanisms for approximately 700 events. The earthquake catalogue reveals clusters of seismic activity and linear trends that broadly align with mapped structures within the Marlborough Fault System, particularly in areas where GeoNet instrumentation is limited. It also shows depth-dependent variations among fault segments. In conjunction with the focal mechanism analysis, these patterns offer new insights into fault geometry and kinematics at seismogenic depths, highlighting the interaction between crustal faults within the Transition Zone and their coupling with the underlying subduction interface.

Beyond vibe coding: developing the Solarium 3D seismic platform with Claude

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Large Language Model Artificial Intelligence (LLM AI) has emerged as a powerful means for fast and effective software development. Inspired by this, and motivated by SeisMomentum Ltd's need for a software platform for geophysical data analysis, we embarked on developing "Solarium" - a Python-based interactive platform, with Claude (Anthropic, 2025; 2026). It soon became apparent that Claude, and the Solarium platform, could support a much richer technical scope than originally envisaged – which we have pursued.

Development began with the definition of high-level specifications. Claude translated this into a set of core components such as data models, data manipulation pipelines, a visualisation canvas, and interactive controls. Claude also recommended and integrated appropriate open-source libraries, and provided phased implementation and testing plans.

Claude's comprehensive knowledge of seismic analysis workflows allowed end-user requirements to be translated rapidly into new code. Even more powerful than this is Claude's breadth of awareness of fundamental mathematical and computational procedures, such as Lanczos resampling for seismic rendering, vectorised Eikonal solvers for complex two-point ray tracing, resolving microseismic event clusters by covariance eigen-decomposition, multi-dataset interactivity in a seismic-to-well tie tool, and ellipsoidal geospatial coordinate transformations.

3D interactive seismic visualisation is usually highly RAM- and GPU-intensive, but we wanted a tool that could run on a modest-specification laptop with integrated graphics only. Using modern programming techniques this has been achieved such that we now have a powerful and portable platform for seismic data analysis, including for basin-scale 3D seismic interpretation.

The development process was not without its difficulties: in particular the specification-to-code translation process would often create unintended outcomes and code failures; and numerical solutions required independent benchmarking of their accuracy. Token usage limits and Claude's context window have also required careful management.

This presentation will discuss the benefits, challenges, and lessons learned from developing Solarium with Claude.

From fragmented data systems to shared capability: the ESNZ Data Platform and AI-ready geoscience

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Aotearoa New Zealand's geoscience depends on extensive and diverse data holdings, but these are often embedded in separate systems, processing workflows and bespoke science applications. This fragmentation makes data difficult to discover and reuse, duplicates technical effort, and limits the consistent application of analytics and artificial intelligence.

The Earth Sciences New Zealand (ESNZ) Data Platform is being developed as a shared capability supporting ESNZ's six science missions: Geological Hazards, Weather and Climate Hazards, Energy, Land and Water, Atmosphere and Climate, and Oceans and Fisheries. It will provide a cloud-enabled foundation for moving selected datasets and science products into scalable, governed, and accessible systems. Standardised capabilities for ingestion, storage, processing, cataloguing, and access allow scientists, analysts and software systems to use data consistently while bringing compute closer to the data.

Rather than replacing domain-specific applications, the platform separates shared infrastructure from scientific content and application development. Science teams can focus on curation, interpretation, and user needs, while the platform provides reusable pipelines, access services, operational monitoring, cyber security, and service governance. Common patterns for example in time-series data, imagery, nowcasting, analytics and AI reduce repeated engineering effort and support reproducible workflows.

The platform will coexist and integrate, where useful, with established data-acquisition and service-delivery programmes such as GeoNet, and in the near future with MetService. This federated approach recognises the value of existing operational systems while enabling data and services to be reused across organisational and disciplinary boundaries.

Although primarily an internal ESNZ capability, the applications hosted on the platform have wider scientific, public and operational significance. The presentation will showcase examples supporting environmental monitoring, hazard understanding, marine science, forecasting, and access to significant data sets. Together, these demonstrate how trustworthy data foundations and interoperable systems provide sustainable pathways from scientific innovation to operational, AI-enabled services.

Utilising citizen science to understand tsunami evacuation behaviour for 2016 Kaikoura and 2021 East Cape earthquakes

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Tsunamis are rare but devastating hazards, and in near-source events official warnings often arrive too late to matter. In these situations, survival depends on people recognising natural warning signs, chiefly strong or prolonged earthquake shaking, and self-evacuating without waiting for confirmation. Aotearoa New Zealand's national campaign, "Long or Strong, Get Gone," is built on this logic, yet it remains unclear whether the public actually applies an "OR" threshold when deciding to move, or whether they wait for both cues together before acting. This gap between intended and actual behaviour is difficult to study directly, since tsunamis strike without warning and rarely permit controlled research.

This study addresses that gap using a citizen science approach, drawing on GeoNet "Felt Detailed" survey reports submitted immediately after the 2016 Kaikōura and 2021 East Cape earthquakes (1,115 and 1,379 responses respectively). Respondents' perceived shaking intensity and duration were combined into three categories, Neither, Long OR Strong, and Long AND Strong, and analysed against evacuation, alongside demographic and hazard-zone exposure variables.

Across both earthquakes, evacuation likelihood rose in a clear, stepwise pattern as shaking was perceived as both prolonged and intense, rather than as either characteristic alone. Respondents meeting both conditions were roughly three (Kaikōura) to four (East Cape) times more likely to evacuate than those meeting neither. Perceived shaking intensity and residence within a tsunami hazard zone emerged as the strongest independent predictors of evacuation, while perceived tsunami likelihood and demographic characteristics showed weaker or non-significant associations once these were accounted for.

Geotechnical decision-making for resilient water storage in Hamilton: from site optioneering to rigid inclusions

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Reliable water storage is important to Hamilton's long-term resilience, particularly as population growth, climate variability and natural hazards place greater pressure on essential infrastructure. This paper describes the geotechnical decision-making for a new 25 ML, 62.5 m diameter reservoir, which has an Importance Level of IL4, from site optioneering to detailed foundation design.

Three potential sites were compared using available geological information and geotechnical data by performing preliminary analyses. The assessment considered liquefaction, slope stability, static settlements, groundwater, buoyancy, ground improvement and foundation requirements, and earthworks and construction challenges. The site along Ruakiwi Road was selected based on the preliminary analyses.

Boreholes, CPTs, laboratory testing and groundwater monitoring were then performed to support detailed design. A probabilistic site-specific seismic hazard assessment was also completed to better constrain the seismic loads and demands over the 100-year design life of the IL4 asset based on site-specific data based on the latest national seismic hazard knowledge, potentially reducing both foundation and structural costs.

The initial foundation solution used surcharging to manage total and differential settlements. As the programme developed, the duration of surcharging, and the environmental effects of importing and removing large volumes of fill made this option less viable. The design was therefore changed to ground improvements in the form of rigid inclusions beneath the reservoir and associated mechanically stabilised earth wall. The adopted system comprises 600 mm diameter continuous flight auger (CFA) inclusions, generally 12 to 14.5 m long, beneath a reinforced granular load-transfer platform.

The project shows how geoscience can guide decisions at the intersection of geohazards, environmental constraints and community needs, while supporting a buildable and proportionate solution for critical water infrastructure.

From information overload to insight: automation and unified dashboards for geohazard response and BAU at NGMC

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The National Geohazard Monitoring Centre (NGMC) generates and consumes large volumes of heterogeneous data during both active response and business-as-usual (BAU) operations from seismic catalogues, satellite imagery, sensor networks, and public reporting streams. Making this data rapidly discoverable and actionable under time pressure is a growing challenge. Meeting it requires not only automating certain tasks, but also bringing an ensemble of information together into a single, coherent view for analysts and decision-makers.

This presentation showcases a number of the different tools that the NGMC uses to display and analyse the information in a meaningful way to support both BAU and Response modes. They have all been developed either entirely or in part by Geohazard Analysts within the centre to enhance our situational awareness and make our operations more efficient and streamlined.

How does Wellington's complex faulting and thermal structure impact seismogenesis?

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Wellington sits at the intersection of large, seismically active geological structures. The region is in the North Island Dextral Fault Belt (NIDFB), where major crustal faults meet the Hikurangi Subduction Zone within a complex plate boundary transition zone, which results in strong heterogeneity in thermal and geological structure. Faulting processes generate seismicity in the region, which is likely strongly controlled by this variation in thermal and geological structure. We interrogate a new detailed seismicity catalogue alongside the latest thermal and frictional models to better understand how these properties control faulting behaviour.

Previous earthquake catalogues in the Wellington region had kilometre-scale location uncertainties, comparable to the scale of the structures being analysed. To enable the mapping of seismicity to faulting, we constrain 947 focal mechanisms for a recent high-resolution relocated catalogue of ten years of earthquakes. This analysis allows us to use earthquake locations and nodal planes to infer fault structures and kinematics at depth. Using these mechanisms, we classify upper plate and slab faulting on major structures in the Wellington Region, and assess whether spatial distribution, rate and style of faulting at depth reflects variations in thermal properties and lithology across the region. This dataset improves our understanding of fault structures and their connectivity, rheological properties and the potential for large, multi-fault earthquakes beneath Wellington.

Small on-fault lakes as multi-millennial sedimentary archives of surface rupturing earthquakes on the Hope Fault

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The plate boundary transition zone in central Aotearoa New Zealand comprises a complex network of strike-slip faults capable of producing multi-fault ruptures, such as the 2016 Mw 7.8 Kaikōura earthquake. Previous studies suggest that earthquakes in these settings may occur in clusters, exhibiting variability in fault activity on millennial timescales. Yet there is a dearth of long paleoseismic records with high chronological resolution, which are needed to constrain the spatiotemporal behaviour of large earthquakes. While lakes have emerged as continuous, high-resolution archives of seismic shaking, attributing this evidence to specific source faults is challenging in settings with dense fault networks. In contrast, most on-fault paleoseismic records (e.g. trenching) provide robust source-fault attribution, but they are often limited in continuity, chronological precision, or record length.

To overcome these limitations, we investigated two small (<50 ha) lakes situated directly on the Hope Fault. Sediment cores from both lakes contain sequences of event deposits characterised using sedimentological, physical and chemical properties and constrained by age-depth models based on ^{14}C, ^{210}Pb and ^{137}Cs dating. The youngest event deposit in both lakes can be attributed to the historical 1888 Amuri earthquake, providing a calibration point for interpreting older events within the sequences. Below the 1888 horizon, the lake sediments preserve evidence of repeated surface-rupturing earthquakes extending back at least 3000 years. These records demonstrate the potential for small on-fault lakes to combine precise source-fault attribution with the continuity and chronological resolution of lacustrine sediment archives. Integration of these records with regional lake-based shaking histories offers a unique opportunity to investigate long-term earthquake recurrence and possible rupture sequences within the Marlborough Fault System.

Quantitative palaeoecology and palaeoenvironmental reconstruction of the Late Cretaceous-Paleogene succession in the Amama-1 and Bara-1 Wells Anambra Basin, Nigeria

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The Amama-1 and Bara-1 wells in the Anambra Basin, southeastern Nigeria, penetrated a continuous Late Cretaceous–Paleogene succession comprising the Nkporo, Mamu, Ajali, and Nsukka formations. This study integrates qualitative foraminiferal biofacies and quantitative multivariate analysis of palynological ecological groups to refine the sequence stratigraphic framework and reconstruct paleoenvironmental and paleoclimatic evolution. Palynological percentage data of nine ecological groups were subjected to hierarchical cluster analysis and principal component analysis (PCA). The results define three statistically significant palynological clusters corresponding to continental swamp-forest, transitional coastal plain, and mangrove-coastal swamp environments. PCA extracts a primary marine-terrestrial gradient (PC1, 48% variance) and a secondary humidity-aridity gradient (PC2, 22% variance). Integration with foraminiferal biofacies and wireline log-derived sequence stratigraphy reveals five paleoenvironmental phases that correspond to systems tracts. Outer neritic conditions in the Nkporo Formation (Late Campanian) are characterized by high planktonic/benthic ratios (>25%) and a palynological cluster dominated by dinoflagellate cysts and mangrove pollen. The Mamu and Ajali formations (Maastrichtian) record a transition to inner neritic–deltaic settings with low planktonic/benthic ratios (<5%) and a palynological cluster dominated by terrestrial pollen and spores. The Paleocene Nsukka Formation shows a return to inner neritic conditions with increasing marine influence and a palynological cluster indicating mangrove-coastal swamp environments. Maximum flooding surfaces at 76 Ma, 73.5 Ma, 69.5 Ma, and 61 Ma coincide with peaks in marine palynomorph abundance and the dominance of marine-influenced palynological clusters. The study provides a high-resolution, quantitatively supported framework for reservoir and source rock prediction in the basin.

~~Keywords: Anambra Basin, palaeoecology, Sequence stratigraphy, foraminifera, palynology, multivariate analysis.~~

Catching marine carbon: using natural analogues to investigate marine carbon dioxide removal approaches in Aotearoa New Zealand

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In addition to cutting and stopping anthropogenic CO_2 emissions to meet international obligations, the IPCC has indicated that direct human interventions will be needed to address legacy carbon, especially from hard-to-abate industries such as transport and cement production. Since marine systems play a critical role in controlling atmospheric CO_2, different marine carbon dioxide removal (mCDR) techniques are now being considered as possible solutions to maintaining the global temperature increase to less than 1.5 or 2°C. These mCDR techniques aim to enhance natural biotic and abiotic processes, and include Ocean Alkalinity Enhancement, Terrestrial Biomass Sequestration, and Ocean Nutrient Fertilisation.

A new five-year Endeavour Research Programme led by Earth Sciences New Zealand, alongside seven national and 12 international partners, will evaluate the risks and potential of these techniques by using a novel approach centred on natural analogues for these approaches in the waters around Aotearoa New Zealand. The Ocean Alkalinity Enhancement study will focus on riverine and groundwater inputs of alkalinity in Te Matau-o-Māui Hawke Bay, with a research campaign conducted in May 2026. Wood deposited on the Hawke Bay continental shelf during Cyclone Gabrielle and other extreme weather events will provide an analogue for Terrestrial Biomass Sequestration. Carbon export to the deep ocean during natural phytoplankton blooms in Subantarctic waters will be evaluated as a proxy for Ocean Nutrient Fertilisation. Improved mechanistic understanding of key marine biophysical and biogeochemical processes will be vital for assessing the effectiveness and validity of mCDR. The research will also deliver methods and protocols for Monitoring, Verification and Reporting (MRV) and Environmental Impact Assessment frameworks that are appropriate to Aotearoa NZ. The main outcomes delivered by the programme will provide government regulators and policymakers with the information needed to make educated decisions around mCDR's applicability to achieving Aotearoa New Zealand's goal of net-zero emissions by 2050.

A review of spatial machine learning techniques relevant to epithermal gold prospecting in New Zealand

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For over two decades, gold prospectivity modelling in New Zealand has relied mainly on GIS-based statistical evidence-integration methods, particularly Weights of Evidence, while spatial machine-learning (ML) approaches have advanced substantially in recent years. National-scale epithermal gold prospectivity modelling began in 2003, with models developed for Northland, Coromandel and the Taupō Volcanic Zone.

This review examines 74 scientific publications, geological studies and exploration reports to assess geoscientific data requirements and recent developments in spatial ML for mineral prospectivity mapping (MPM). Specifically, it addresses three questions: (1) what geoscientific datasets are available in New Zealand and are relevant to epithermal gold prospectivity modelling; (2) what techniques have been applied to epithermal gold prospectivity modelling in New Zealand; and (3) which spatial ML techniques are employed in recent MPM studies.

For New Zealand, key datasets are available through Earth Sciences New Zealand and New Zealand Petroleum & Minerals, including QMAP geological mapping, the GERM mineral occurrence database, Petlab geochemical data, and national and regional geophysical surveys. However, the datasets within these data sources were collected over different time periods, some legacy datasets lack systematic updates, and spatial coverage is uneven. Ground-truth data present an additional challenge, as they are limited to positive and unlabelled samples, with no explicitly labelled negative examples.

We conclude that recent studies increasingly employ deep learning (DL) techniques alongside conventional algorithms because such techniques can capture complex, non-linear relationships among features. Despite the expanding application of DL techniques, model performance is often more strongly influenced by training-data quality, spatial bias, and the representation of geological evidence than by algorithmic complexity.

The next stage of this research will develop and apply a reproducible spatial data framework for New Zealand and evaluate recent spatial ML techniques to identify the most effective approach for epithermal gold prospectivity mapping.

Central Rangitīkei geological map, eastern Whanganui Basin

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The Plio-Pleistocene marine sedimentary succession of the eastern Whanganui Basin is well exposed in the Rangitīkei Valley, lower North Island. The mapped area covers 1,600 km^2, extending from the Whangaehu River-Mangamahu Stream confluence and open terrace country around Marton in the west to hill country around Ōhingaiti, Pakihikura and Waituna West in the east.

The marine succession (~3.7– 0.6 Ma) and overlying terrace cover-beds (<0.5 Ma) represent one of the most complete Quaternary stratigraphic records found on land anywhere in the world. It also preserves an internationally significant record of global sea-level and climate change. Chronostratigraphic subdivision is based on lithofacies, fossil assemblages and volcanic deposits from the Taupō Volcanic Zone. Identification and geochemical fingerprinting of the first influx of a particular tephra or pumice allows for basin-wide correlation and provides a robust framework for dating and correlation.

A new 1:25,000 geological map and accompanying bulletin have been compiled, incorporating new mapping and the work of previous authors over the last 75 years. The mapping identifies a complex of en echelon structures that dissect this actively uplifting marine basin and provides a revised stratigraphic framework linking the western and eastern parts of the study area. Together, the maps and bulletin provide an updated geological framework for understanding the stratigraphic and structural evolution of the central Rangitīkei and a consistent basis for future mapping and fieldwork. Tephrostratigraphy and biostratigraphy link the local succession to the established Whanganui Basin chronostratigraphic framework, including the astronomically tuned $\delta^{18}O$ record and geomagnetic polarity timescale.

New constraints on the source of the 1929 Mw 7.0 Arthur's Pass earthquake

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The 1929 Mw 7.0 Arthur's Pass earthquake caused intense shaking felt across much of Aotearoa New Zealand and resulted in the closure of West Coast Road (now State Highway 73) for several months while landslide debris was cleared. This earthquake received little study at the time, due to its remote alpine location and because attention shifted to the more destructive Mw 7.3 Buller earthquake three months later. Previous reconnaissance work delineated a thin NE–SW trending region of coseismic landslides c. 40 km in length in the eastern part of Arthur's Pass National Park, and a 16 km potential surface rupture on the Poulter Fault. The recent release of new airborne lidar data in this area allows for a more detailed assessment of potential coseismic surface rupture. We combine this lidar with orthorectified historical aerial photographs from 1938–1965 to further refine areas of high coseismic landslide densities as a proxy for strong ground shaking.

Our mapping has revealed several subtle (<1 m height) previously unmapped fault scarps on Late Quaternary geomorphic surfaces within the area of highest coseismic landslide density. Some scarps have a 'free face' or are found on active scree slopes at >1500 m elevation suggestive of a very recent (historical) formation. Our mapping evidence combined with a refined coseismic landslide distribution suggests that the earthquake could have ruptured multiple adjacent steeply dipping NE–SW faults, rather than a single fault rupture. We will combine these data with high-resolution ground motion simulations from several plausible earthquake sources, to test which surface rupture(s) aligns best with the distributions of coseismic landslides.

Integrated UAV-based magnetic, gamma, and electromagnetic surveys as a means of refining and objectifying geological maps in difficult-to-reach areas of mountainous regions of Eastern Eurasia

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Geological maps are the foundation of subsoil management; however, they are inherently subjective rather than objective information products. Furthermore, they are often characterized by insufficient observation density and the difficulty of obtaining information in conditions of low bedrock exposure (which is typical of most regions promising for the discovery of new deposits). Geological prospecting is currently being conducted primarily in areas that are difficult to pedestrian access and remote from infrastructure, and the objects of prospecting are blind deposits. Geophysical methods allow for obtaining detailed and objective information about the geological structure of both surface and subsurface of an area, but they are even more prone to difficulties of pedestrian accessibility than geological observations, and the use of traditional airborne geophysical surveys from manned platforms is generally unprofitable for areas up to a few hundred square kilometres. Therefore, UAV-based geophysical methods have become widespread in recent years, primarily magnetic surveys using multirotor platforms. Lightweight UAV systems are easily deployed to a site and enable rapid, detailed surveys within a radius of several kilometres from the takeoff point. However, the true power of geophysics lies in its integration, and this report, using a series of real-world gold prospecting cases in the mountainous regions of Northeast Eurasia, demonstrates how the use of a combination of three UAV-based methods—magnetic surveys, gamma surveys, and electromagnetic soundings in the frequency and time domains—allows for the refinement of existing geological maps at scales of 1:200,000–1:50,000 to scale 1:10000–1:5000, and how significant and costly geological errors were avoided as a result of such surveys. The specific methods for conducting all three types of geophysical exploration using low-altitude UAVs are discussed in detail, and recommendations for the effective implementation of such work are provided.

A study of the of natural variability of hydrogeochemical parameters of Lake Baikal (UNESCO Heritage) as a long-term basis for environmental training of geology students

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Today, specialists in geological prospecting and exploration must not only be well-versed in environmental standards across various countries but also deeply understand the environmental science underlying their development. For example, natural concentrations of various metals in soil, water, and plant components within ore-prospective provinces can significantly exceed national MPC standards, and environmental risks for new mining projects can only be avoided through qualified geoecological research conducted in conjunction with geological prospecting. To help students gain a practical understanding of the complexity of assessing natural geochemical norm ranges and learn to work in unusual geosystems, the Siberian School of Geosciences of Irkutsk Technical University, which graduate geology students in eight different specializations, is implementing an annual program of hydrogeochemical monitoring of the near-surface waters of Lake Baikal and Angara River. Lake Baikal is a unique natural area with a distinctive geochemical background and biota. Economic activity within its waters is ongoing, and the debate about its current ecological state is rooted precisely in the difficulty of classifying changes as natural or man-made. The report demonstrates how, thanks to the massive participation of dozens of students, previously trained in cruising yacht handling, it became possible to obtain up-to-date hydrogeochemical data from more than 100 monitoring points located across a large area several times a month. This allows for the creation of a unique database of annual changes in water chemistry. The students also created a public geoportal where the research results are displayed in situ. The program generates important scientific data, motivates students, provides them with real-world data and practical experience in environmental disciplines, and enhances the University's reputation and supports its long-standing academic tradition, according to which all graduates of the Irkutsk School of Geosciences, beginning in the mid-18th century, were skilled in working on sailing ships and on maritime expeditions.

Toward forecasting gas-driven volcanic eruptions using integrated field data and modelling

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Gas-driven (phreatic) eruptions are one of the most common types of volcanic eruption in New Zealand and are notoriously difficult to forecast. Forecasting efforts can benefit from holistic, model-driven approaches that investigate a system's evolution and physical state prior to eruption, particularly when combined with multiple types of monitoring data. Our approach is built on two key components: a forward model based on field data that explores potential pre-eruptive conditions, and an inversion technique that can find which conditions best fit observed monitoring data. Using this workflow, we have developed heat and fluid flow models and coupled them with degassing data from Whakaari / White Island Volcano.

We used Waiwera software to explore 3D permeability and gas flow conditions associated with pressure build-up within a volcano-hydrothermal system. Models were informed by rock property data, electrical and electromagnetic resistivity images, and multidisciplinary conceptual models from Whakaari. Fluid flow models show that reduced permeability within a volcanic edifice due to hydrothermal mineralisation is a key factor for overpressure that could lead to a gas-driven eruption.

To calibrate our models, we assimilated gas flux and ground temperature data into Waiwera models using the Ensemble Kalman Filter (EnKF). The EnKF produces an evolving suite of models that track how variations in hydrologic conditions and magma-derived fluid flow rates change the system's pressure and temperature, and the associated monitoring signals. Our results suggest episodes of pressurisation have occurred that can be compared with observed volcanic unrest, but also highlight that individual monitoring observations do not uniquely constrain subsurface permeability and magmatic gas input. Our method provides insights into volcano-hydrothermal systems prior to gas-driven eruptions, and has potential as a monitoring tool to aid holistic interpretation of monitoring data.

Visible Geology in a first-year geological mapping laboratory: Evaluation of implementation and student outcomes

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Spatial skills are an invaluable tool for geoscientists as they provide the basis for visualizing, projecting, manipulating and interrogating subsurface structures. 3D visualisation of geological features is a challenging component of first geology education at university. Classroom-based laboratories typically use 2D Maps, cross sections and drawings, physical block models, field photos, and PowerPoint slides to teach geological mapping.

Visible Geology, an initiative by Seequent, The Bentley Subsurface Company, is a free, browser-based tool for creating and manipulating virtual geological structures in 3D. Users can shape the topography of block models, add geological units, impose structures (e.g., folds, faults, intrusions) and view a geological history. Here, we pilot the integration of five Visible Geology-based lesson plans into first year mapping laboratory sessions to quantitatively and qualitatively assess its efficacy at improving student spatial skills.

Qualitative pre-course survey data show the majority of students have (1) little previous experience with geology, (2) hike less than once every six months, (3) do not have formal training in spatial software, and (4) play computer games more than once a month. Quantitative, pre and post-laboratory spatial skills tests show a small overall increase in student spatial skills. Post-laboratory survey responses frequently mentioned Visible Geology as useful, easy to use and explore, and it consistently ranked highly among preferred learning tools. We conclude that this type of visualization tool is a useful addition to the geoscience teacher's toolbox. In addition, we encourage other instructors to utilise the free resources and explore more research into how the tool can be used to add value to the geoscience curriculum.

The UC Earth Science Garden: where to next?

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The UC Earth Science Garden, opened at the University of Canterbury's Christchurch campus in April 2025, is New Zealand's first and one of the few map-based teaching rock gardens worldwide. It is arguably unique, providing an integrated approach to geologic and environmental learning using landscape layering underpinned by rocks from around Aotearoa and structural features. Over a year since opening, the garden continues to expand its offerings for tertiary students, schools, and community groups, spanning from preschool tamariki to retired adult learners.

A recent addition, developed with UC Civil Engineering's 3D-printed concrete research group, is an experimental fold sculpture. Representing real field structures, on a smaller scale, it provides a hands-on experience close to the classroom for the development of crucial field skills.

The garden also displays fossils (both prepared and in situ) ranging from small shells to a 1,000+ kg Cretaceous plesiosaur, with tactile access encouraged to foster direct engagement with ancient life. Primary school lesson plans, created with teacher input and aligned to the NZ curriculum, cover core geological concepts, field science methods, and fossil evolution. For broader public engagement, the team has produced a Geology Exploration Trail and an EarthCache registered with Geocaching NZ.

Future development includes a discovery rock seat built from historic rock slabs salvaged from the Geology Department dismantled after the Canterbury earthquakes, plus thin-section imagery, 3D digital models, and augmented reality to deepen storytelling. Ecological additions such as a butterfly garden and insect monitoring linked to native plantings, will strengthen biodiversity connections. To sit alongside the widely loved volcano-in-a-barrel demonstration, a new meteorite sculpture with an associated lesson plan is in development.

Continued collaboration with Ngāi Tahu will bring regional pūrākau (cultural narratives) illustrated by local artists and a braided river sculpture symbolizing the Canterbury Plains, linking Mātauranga Māori with geoscience.

Fault slip history of the Whakaipō Fault, Taupō Volcano

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The Taupō Fault Belt within the modern Taupō Rift contains faults that have been active in the last 25 ka and, given the high frequency of Holocene eruptive activity at Taupō Volcano, faulting and volcanism in the area are likely linked. The Whakaipō Fault is one of four main faults in the Taupō Fault Belt, just north of Lake Taupō. Recent studies have found evidence for significant fault motion on this fault during and after the 232 CE Taupō eruption. However, no work to date has confirmed the earthquake recurrence along this fault and whether similar tectonic-volcanic interactions occurred in the ~20 kyr prior to the 232 CE eruption.

To address this issue, we examined an exemplary road cut exposure of the Whakaipō Fault, which allows us to reconstruct its fault slip history. This outcrop shows more than ten individual Taupō volcanic deposits, several of which are topped by paleosols/soils, each with varying thicknesses and deposition mechanisms. These units have been cleanly cut by the fault, with minimal tilting, erosion or reworking of footwall material.

A structural restoration of the fault was performed by lining up the base of each volcanic unit across its hanging wall and footwall exposures, and the timing of faulting based on the ages of the displaced Taupō volcanic deposits. Our results provide a recurrence interval estimate of ~1500 years for the Whakaipō Fault, based on evidence from the last ~10 kyr of fault activity. Volcano-tectonic interactions are only observed during the Taupō 232 CE eruption and are consistent with previous studies for this fault system. These findings demonstrate that co-eruptive fault displacements on the Whakaipō fault are temporally and spatially linked to only the largest eruptions from Taupō volcano.

The petrology and geochemistry of igneous rocks found in the central portion of Tsezhin Bii/Hopi Buttes volcanic field, northeastern Arizona.

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A preliminary presentation of the petrology and geochemistry of igneous rocks found in the central portion of Tsezhin Bii/Hopi Buttes volcanic field in northeastern Arizona. Tsezhin Bii is a monogenetic intraplate volcanic field of Miocene age located in the southern portion of the Colorado Plateau. The central portion is significant for its high density of vents, the range of eruptive styles and complexity relating to the overlapping of vents and extensive reworking of volcanic sediment. This central portion is also significant in terms of the findings of large cognate mica-bearing pyroxenite nodules and associated megacrysts. Preliminary findings involve a review of major oxides, trace elements, Sr-Nd-Pb isotope analysis and EPMA data for selected mafic minerals within the extrusive volcanic samples. These results have been used to report on the classification of these rocks, the depth and conditions of magma generation, and the pathways of magma ascent to the upper crust.

Basalt lava, hyaloclastite and a water-saturated environment combine to preserve 2.57 million-year-old wood at Te Mata, western North Island

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Mummified (non-mineralized fossil) wood occurrences ranging from Paleocene to Pleistocene in age have been reported globally, where burial conditions have created a sterile, chemically inert environment that is impermeable to mineral-bearing groundwater. This work describes a study of well-preserved logs and branch fragments, some including bark, which have been found beneath the Wairēinga Falls basalt lava, part of the Okete Formation, in a quarry near Te Mata, that has previously been dated at 2.57 Ma. The work includes geological field observations, petrographic and geochemical studies of the host deposits, and wood microscopy and chemical/spectroscopic analyses. The olivine basalt lava, up to ca. 38 m-thick, has infilled a palaeovalley cut through Oligocene Te Kuiti Group sand and siltstone; it features varying joint spacings and orientations, including a rosette form and a lava tube, representing multiple channelised flow units.

Mummified wood fragments, including examples anatomically similar to modern southern beech (*Nothofagaceae*) and a conifer, possibly *Podocarpus totara*, occur at the top of the substrate directly beneath the lava flow. The brown wood and bark commonly show well-preserved cellulose and lignin structures but often have charred surfaces with degraded cellular structures; darker wood or charcoal are more degraded. Some wood surfaces show fine surficial pyritization. The substrate is locally characterised by a ~5 cm-thick black charred horizon overlain sharply by pale white clay-rich hyaloclastite consistent with quench fragmentation of the lava flow over a water-saturated, organic matter-rich surface. The fortuitous combination of a potentially anoxic, water-logged, woody environment (e.g. a swamp); rapid burial, sterilisation and limited charring by a thick basalt lava; and sealing by an impermeable hyaloclastite sediment ‘blanket’ is likely to have led to the long-term preservation of logs and branches. The thick lava has also protected the underlying soft strata from subsequent erosion.

The mineralogical changes of carbonate rocks induced by hydrogen

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New Zealand's goal to reach net zero carbon by 2030 can be aided by the adequate storage of hydrogen for later energy production. Underground sedimentary structures in depleted petroleum sites are promising as large long-term hydrogen storage reservoirs. A combination of previous models and experiments into the reactions between hydrogen and carbonate show contradicting results to how they would behave in an underground storage setting. Previous work on the Mangahewa sandstones from the Pohokura-3 well in Taranaki looked at the geophysical changes in porosity and permeability after brine and hydrogen exposure, this study investigates the subsequent geochemical reactions of these samples for future storage opportunities.

Bulk and micro-scale geochemical changes are being assessed using electron microprobe analysis (EMPA) before and after brine and H_2 ageing of the sandstone samples. With this method site-specific characterisation on hydrogen-driven reactions and their potential effects on cement alteration will be identified. Adverse geochemical reactions between H_2 and carbonate minerals may result in dissolution, precipitation, and hydrogen loss, potentially altering permeability and porosity while compromising hydrogen storage capacity. Conversely, if no significant geochemical reactions occur, the results will present encouraging evidence for the long-term viability of underground hydrogen storage in New Zealand.

From information to action: a global review of public landslide preparedness and mitigation guidance

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Landslides are a persistent and damaging hazard in Aotearoa New Zealand. Risk is likely to increase as population and development expand and rainfall patterns change. Public information often explains what landslides are, warning signs to look for, and what to do during or after an event. It can be harder for people to turn this information into practical decisions about their property, preparedness, and affordable ways to reduce risk before a landslide occurs.

This applied review, undertaken for Natural Hazards Commission Toka Tū Ake, examines how public landslide preparedness and mitigation guidance is communicated internationally, and what lessons it offers for Aotearoa. Openly accessible websites, maps, checklists, brochures, decision aids, and guidance are being identified through structured Google searches across selected countries, as well as targeted searches of credible organisations. Each product is assessed using a framework drawn from risk communication, disaster preparedness, protective action, and landslide-map design literature. The review considers how well each product supports people to understand their risk, recognise warning signs, decide when to act, choose practical and affordable mitigation steps, and find trusted, accessible, and connected information.

The presentation will highlight key findings from the global review, using examples from different contexts to show what may help or hinder public understanding and action. It will consider what these lessons mean for New Zealand homeowners, homebuyers, renters, and communities, and for landslide risk research and practice in Aotearoa. The presentation will focus on the gap between hazard knowledge and household decisions, the limited evidence on user testing and effectiveness, and the research needed to develop guidance that is accessible, trusted, and locally relevant.

Co-designing rainfall-induced landslide forecasts for Aotearoa New Zealand

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As New Zealand faces rising natural hazard risks driven by climate change, delivering actionable landslide intelligence is critical. The five-year Hōretireti Whenua Sliding Lands Endeavour Programme addresses this by developing Aotearoa's first national-scale, real-time landslide forecasting system. This study presents findings from semi-structured interviews with 25 participants from a range of sectors, iwi/hapū and the public, evaluating prototype landslide forecasts issued during the devastating 2023 North Island Severe Weather Events.

While the wider evaluation identifies barriers to uptake such as low model familiarity and technical capacities, this presentation focuses on the sector-specific operational requirements we have mapped. Results reveal that forecast preferences are highly sector dependent. Emergency managers prioritise regional, interactive GIS maps with long lead times (3 to 7 days) and exhibit high uncertainty tolerance. In contrast, local government users require suburb-level (SA2) resolution with carefully managed uncertainty communication to help prevent the perceptions by the public that they are 'crying wolf'. Meanwhile, infrastructure providers have low utility for abstract uncertainty, preferring asset corridor maps linked to specific operational triggers. Scientists would like weather forecast uncertainty and scenario-based 'best/worst-case' planning tools.

Ultimately, these distinct requirements for scale, visualisation, lead times, and update frequencies highlight that a one-size-fits-all forecasting system is ineffective. Instead, we present a sector-specific co-design framework to successfully integrate landslide science into New Zealand's diverse anticipatory action, response, and recovery workflows.

Future perturbations of atmospheric chemistry by *Pinus radiata* – why silvicultural carbon sequestration will exacerbate emissions problems and climate change

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Pinus radiata D. Don has been planted extensively in New Zealand with the intention of offsetting anthropogenic emissions of CO_2, a long-lived greenhouse gas, via drawdown of atmospheric CO_2 and sequestration of carbon in plant tissues.

However, the wood of radiata pine is not durable, the plant has a short lifespan (< one century), and the species does not re-establish under a mature pine canopy. This leads to the inference that soon after 2100, forests planted for 'carbon farming' in the early 21st century will emit approximately one century's worth of drawn down carbon in a few decades unless silvicultural management practices are modified to prevent this. Senescent *P. radiata* trees will be too large and piece weights too great to handle using conventional silvicultural harvest methods and equipment. Considered collectively, these factors indicate that unless the management of New Zealand's exotic carbon forests is revised, an unmanageable carbon forestry estate will eventually become a prodigious emitter of CO_2 and, crucially, methane.

During growth, radiata pine emits biogenic volatile organic compounds (BVOC) including the monoterpenes pinene and limonene. The atmospheric fate of these and other BVOC involves breakdown via reaction with atmospheric hydroxyl radicals. These radicals play a key role in moderating the atmospheric concentration of methane, a potent greenhouse gas. BVOC emitted by radiata pine compete with methane for hydroxyl radicals.

Cultivation of radiata pine to offset anthropogenic emissions is predicted to suppress removal of atmospheric methane during a tree's life. Senescence and decay of carbon forests will result in return of all sequestered CO_2 back to the atmosphere at a much faster rate that it was originally drawn down. These processes will significantly perturb atmospheric chemistry in ways that appear not to have been taken into account when New Zealand's emissions and climate change policies were formulated.

Estimating tsunami casualties using agent-based evacuation models

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We describe how models of human fragility can be combined with agent-based models of tsunami evacuations to estimate the number of casualties in different scenarios. Agent-based evacuation models can simulate the decision-making and movement of individual simulated people (referred to as 'agents') during a tsunami evacuation and can be used to investigate the consequences of different evacuation behaviours, such as the effect of delays in starting to evacuate. When overlaid with spatial information on the timing of tsunami arrival and the depth of tsunami inundation, we can estimate the number of people directly exposed to the inundation. By also incorporating a model for human fragility - the likelihood of injury or death for a given water depth - estimates of the numbers of casualties can be obtained. We illustrate this with examples from the Wellington region and show how the information obtained can be used to evaluate and optimize different evacuation strategies.

Reconstructing the volcanic evolution of Rapa Nui (Easter Island) from the seafloor to the subaerial edifice

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Rapa Nui (Easter Island) is the emergent portion of a large shield volcano in the southeastern Pacific Ocean, representing less than 1% of its total volume. Although the island is classified as volcanically active, no robust radiometric ages currently confirm Holocene volcanism, leaving the timing and evolution of its most recent activity uncertain. The present study investigates the spatial and temporal evolution of Rapa Nui volcanism through geomorphological and morphometric analysis of both the submarine and subaerial portions of the edifice. To achieve this, a new bathymetric model was compiled from available datasets with resolutions ranging from 450 m to 25 m, and combined with a 1 m resolution integrated DSM–DTM of the island. Geomorphological mapping identified major volcanic structures, landslides, marine terraces, volcanic alignments, and 173 offshore and 72 onshore monogenetic volcanic landforms. Morphometric parameters were calculated for selected offshore and onshore landforms, while the degree of erosion of 30 onshore scoria cones was assessed using the Average Erosion Index (AEI). The spatial distribution of volcanic landforms indicates control by NE–SW and NNE–SSW trending structures and radial fractures, while cone development and eruptive style differences between submarine and subaerial monogenetic volcanism suggest an influence of hydrostatic pressure and magma–water interaction. Onshore morphometric variability and low AEI values in several scoria cones, together with the preservation of a tuff cone on the insular shelf, suggest recent volcanic activity. These results highlight the potential for late Quaternary to Holocene volcanism on Rapa Nui and identify targets for future geochronological investigation.

How does seismic anisotropy change with Slow Slip Events?

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The offshore Hikurangi margin hosts Slow Slip Events (SSEs; ground movement similar to earthquakes but released over days to years instead of seconds). SSEs could trigger large, tsunamigenic earthquakes. We examine the relation between seismic anisotropy, SSEs and regular earthquakes, focusing on the Pōrangahau region near the border between a region with many SSEs and a "locked zone" without SSEs, where stress is building up, possibly leading to large earthquakes. We use data from the "Processes UnderLying Slow Earthquakes" (PULSE) network of ocean bottom seismometers (OBS)s, temporary and permanent Geonet stations. The shear-wave splitting method measures anisotropy delay time and fast-azimuth orientations, while the Wadati approach measures the Vp/Vs ratio. The spatial average of the fast direction yields an azimuth parallel to the trench in onshore areas, and perpendicular offshore. These results suggest that microcracks align parallel to the maximum horizontal stress (SHmax). The onshore results match previous SHmax measurements for the lower plate earthquakes that make up most of our dataset, suggesting normal faulting and extension due to bending in the downgoing plate. Offshore the plate may be experiencing compression perpendicular to the slab. Some stations, both onshore and offshore, experienced an increase in average Vp/Vs from 1.795 to 1.846 (±0.008) and a decrease in delay time from 0.169 to 0.093 seconds (±0.0146) 15 days before the 2021 Pōrangahau SSE, for a confined cluster of events. Seismicity increases at the same time as the changes in the anisotropy delay time and Vp/Vs. The preliminary interpretation is the increases in seismicity and VpVs, combined with decreasing delay times, highlight the role of fluids as pore-fluid pressure migrates to the upper plate, reducing the effective normal stress and triggering SSEs. We are also examining whether spatial variation in anisotropy combined with earthquake migration may explain the variation.

Lake Rotomahana natural land barrier

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The Rotorua Catchments team at Toi Moana Bay of Plenty Regional Council delivers land and lake restoration activities aimed at reducing nutrient availability, to improve water quality and the overall health of Rotorua Te Arawa Lakes. The team is also responsible for lake outlets, where active lake level management is undertaken to protect people and property.

This presentation focuses on Lake Rotomahana and the management of its outlet area. The lake was substantially altered by the 1886 Tarawera eruption, when a lahar formed a natural land barrier between Lake Rotomahana and Lake Tarawera. The volcanic material infilled the former Kaiwaka Stream Valley between the two lakes. Lake Rotomahana subsequently rose by around 39m above the level of Lake Tarawera.

In the late 1970s, a 600 mm overflow pipe was installed through the barrier to provide a controlled discharge pathway to Lake Tarawera during periods of elevated lake levels of Lake Rotomahana, reducing the risk for uncontrolled overtopping of the natural barrier between the lakes. Previous assessment has estimated that should a breach of the natural land barrier occur, the level of Lake Tarawera could rise between 1.9–4.9 m (Opus International Consultants, 2007), with potential flooding impacts downstream on the Tarawera River.

With the support of technical specialists, the Lake Rotomahana Natural Barrier Monitoring Procedure has been developed. Monitoring and maintaining the outlet and land barrier is a risk-management activity that helps identify change, support emergency preparedness, and improve understanding of possible flooding, erosion, seepage, or barrier-stability risks.

Advances in geological mapping and the geological map product

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Geological maps are fundamental for conveying understanding of geology for a wide range of environmental, resource management, engineering and scientific applications. ESNZ's geological maps of Aotearoa New Zealand have been compiled and published since the mid-1800s, available exclusively as printed copies until 2003 and since 2010 almost exclusively as various digital data products. The new generation products include printable geological maps that retain traditional contextual elements such as a legend and cross sections, delivered in digital file formats that can incorporate layer visibility options on-screen. Other digital data products and delivery bring GIS data to the user via web services and download as well as visibility and content enquiry through web browser map applications.

Geological map GIS data are ideally rich in information (attributes), consistently structured with controlled content wherever possible and described with rich metadata. Incorporation of data standards such as logical data models and controlled vocabularies are important for data interoperability and exchange. Well-applied geoscience information standards and metadata help achieve geological map data "readiness" for Artificial Intelligence tool ingest.

Geological map datasets increasingly share information with related products such as the NZ Community Fault Model, NZ Active Faults Database, Pluton Map and groundwater models. The datasets also provide key lithological information to models of landslide susceptibility, aggregate opportunity and critical mineral prospectivity amongst others. Geological maps are benefiting significantly from interpretation of very high-resolution digital elevation models produced from lidar terrain data, revealing many subtle landscape features including new areas of slope instability and active faults. Airborne geophysical datasets, particularly derived aeromagnetic images, are providing information on subsurface composition and structure for sub-Quaternary and 3D geological models. These developments demonstrate how geological maps have evolved from stand-alone products into increasingly connected digital geoscience datasets that support a wide range of applications.

Geological CO_2 storage suitability assessment in New Zealand onshore saline aquifers

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Most permanent carbon dioxide removal methods depend on CO_2 geological storage (CGS) in underground formations such as depleted reservoirs and saline aquifers. Saline aquifers are particularly advantageous CGS targets because of their potentially large storage capacities and proximity to major existing emission sources. In this study, we evaluated the CGS potential of (saline) aquifer systems across New Zealand by developing a basin screening and ranking framework tailored to the country's geological setting. The framework considered technical, environmental, and social factors under several different storage-mechanism scenarios including both dissolved-phase and gaseous CO_2 injection.

Evaluations of dissolved CO_2 storage primarily focused on five significant factors: water resources, CO_2 sources, infrastructure, hazards, and geological characteristics. Assessment of gaseous CO_2 storage examined the impacts of containment, storage capacity, and feasibility criteria. Within each group, three CO_2 source conditions are considered: Direct Air Capture (DAC), industrial major point sources, and no source constraint. The results indicate that New Zealand's sedimentary basins generally have greater suitability for dissolved CO_2 storage than for conventional gaseous CO_2 storage. Scenarios incorporating DAC consistently achieve higher suitability rankings, whereas scenarios relying on industrial point sources rank lower, reflecting New Zealand's limited number of large stationary CO_2 emitters. Effective CO_2 storage capacity was also estimated for potential saline aquifers within basins classified as having moderate to very high suitability. Although dissolved storage provides lower capacities than conventional gaseous storage, both approaches offer sufficient capacity for long-term CO_2 sequestration. The identified suitable aquifers could potentially accommodate several decades of New Zealand's current annual CO_2 emissions, enough to meet national emissions-reductions targets. Among the onshore sedimentary basins assessed, the Taranaki Basin exhibits the highest overall suitability and storage capacity, exceeding 10 Gt across all scenarios. The South Auckland–Waikato and Southland regions follow, each offering enough capacity across different storage scenarios.

Tracking the disturbance of seabed during anchoring operations

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Ship anchoring is a known source of seabed disturbance, yet the short-term impacts during anchoring operations remain poorly documented. For example, transport of resuspended seafloor sediments can extend beyond the anchoring footprint, exposing adjacent benthic habitats to elevated concentrations of suspended sediments and associated contaminants. We present real-time measurements that tracked the resuspended sediment plume from anchoring disturbance of a ~70 m-long vessel in ~22 m water depth in Te Whanganui-ā-Tara Wellington Harbour, Aotearoa New Zealand.

Vertical profiles of water column conductivity-temperature-depth (CTD) and beam attenuation revealed substantial sediment resuspension following the anchoring event, producing a near-bottom turbid layer approximately 2 m thick that remained evident 24 hours after the vessel was anchored. The resuspended sediment was subsequently transported by bottom currents, and the sediment plume was tracked ~1.5 km northwest of the anchoring site, during incoming tide and measured bottom currents ~5 cm/s. Additionally, turbidity increases were measured in surface waters down to ~10 m during anchor and chain recovery, associated with the sediment released during chain cleaning, a standard practice in Aotearoa New Zealand and many ports worldwide.

Our observations provide direct evidence that impacts from ship anchoring extend beyond the immediate anchoring site. The magnitude and spatial extent of these sediment plumes will depend on seafloor sediment type, local hydrodynamics, such as tides, and type of anchoring operations.

These findings highlight the need to consider sediment plume generation and transport when assessing and managing the environmental impacts of anchoring in increasingly congested ports and harbours, but especially in more pristine waters or regions with high tourist traffic that are being more frequently visited by large cruise ships.

Rapid submarine caldera collapse during the 2022 eruption of Hunga volcano (Tonga)

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Caldera volcanoes produce the most hazardous eruptions worldwide, yet their formation is rarely observed, especially in the submarine environment. This exposes a critical gap in global preparedness for submarine volcanic hazards. Here we present the geomorphic evolution of Hunga volcano (Tonga) after the 15th of January 2022 eruption, providing new insights into the mechanisms of caldera eruptions.

We use repeat high-resolution seafloor mapping to quantify changes in geomorphology after the 2022 climactic eruption. The shallow caldera deepened from ~150 m to ~850 m, with its structural caldera floor ~150 m below infill, and marginally widened from ~4.5 to 4.8 km in diameter. The total displaced volume is 8.9 ± 0.1 km³. Of this, 6.85 ± 0.05 km³ is attributed to caldera collapse, with the remainder due to surface erosion by eruption-fed density currents. Our post-eruption bathymetry revealed landslide deposits intercalated with pyroclastic infill, implying syn-eruptive caldera collapse, and inward-stepping terraces, which we interpret as surface normal fault splays over piston subsidence. The caldera and magmatic system geometry suggests that ~8 km^3 of Dense Rock Equivalent magma erupted to initiate collapse, less than 30% of the magma reservoir. Our results imply that rapid caldera collapse during major submarine eruptions can radically transform ocean structure, processes and composition, as well as eruption hazards, such as generating extreme density mass flows and volcanic tsunami.

Our study underscores the urgent need for high-resolution repeat seafloor mapping to capture the dynamics of submarine caldera formation and collapse. These time-series datasets are essential for improving submarine volcano hazard monitoring, strengthening tsunami early-warning systems, and protecting critical seafloor infrastructure, particularly in poorly surveyed regions such as the southwest Pacific.

The 1855 Wairarapa Ms ~8.2 earthquake and tsunami: historical data, seismic rupture models and numerical modelling

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On 23 January 1855 an earthquake of estimated magnitude Ms ~8.2 struck east of Wellington, in the Wairarapa Valley. Felt almost everywhere in New Zealand, it killed at least 9 people and had substantial impacts on colonial era buildings, especially in Wellington. Later investigation showed that this earthquake resulted from a up to 160-km rupture on the Wairarapa Fault, a dextral strike-slip fault showing a significant vertical uplift component. Field surveys estimated the dextral slip on the fault reached at least a maximum of 18.7 m and the vertical slip ~2.5 m. This notably resulted in uplift of parts of the region, with a maximum of 6.4 m of uplift measured at Turakirae Head at the southernmost tip of the Remutaka Range. Previous studies suggest that this crustal fault rupture might have extended downdip, being able to merge with the Hikurangi subduction interface.

170 years later, the Wairarapa earthquake is still the largest in New Zealand in modern history. It is potentially one of the largest strike-slip earthquakes prior to the instrumental era, second only to the 2012 Mw 8.6 Indian Ocean earthquake off Indonesia.

Historical testimonies report that a set of tsunami waves followed the earthquake and most affected the Cook Strait region and its vicinity, while being reported further away as well. The largest tsunami height is known from eastern Palliser Bay, where it reached an estimated altitude of ~10 m while Wellington Harbour experienced waves of ~1.5-2 m in height.

This study aims at using our current understanding of the Wairarapa Fault and Hikurangi subduction interface to simulate the ground deformation associated with the earthquake and the subsequent tsunami on a reconstructed pre-earthquake topography of the region. The simulation outputs are compared with uplift/subsidence data and tsunami historical accounts to assess our ability to reproduce the event.

A record of the 2016 Kaikōura tsunami in Porirua raises questions about its source mechanisms and location

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On 14 November 2016, the destructive Mw7.8 Kaikōura earthquake struck the east coast of the South Island of New Zealand. It was quickly followed by a tsunami which affected ~200 km of coastline with run-up heights of as much as 6.9 m. The tsunami was recorded by many coastal gauges, at least as far as the Chatham Islands.

Various studies of the Kaikōura tsunami have only considered wave records from the east coast of the South Island and the Chatham Islands. Proposed tsunami source models, including that of Gusman et al. (2018) involving joint inversion of tsunami waveforms and vertical displacement data, are able to reproduce the coastal gauges' waveform records reasonably well in terms of amplitude, arrival time, and phase, at least for the first couple of hours. However, the discovery of an additional timeseries in Mana Marina, Porirua, which shows a clear record of the tsunami wave train with a maximum amplitude of ~40 cm, raises new questions. Using Gusman et al. (2018)'s source model, we have simulated the Kaikōura tsunami on a new Digital Elevation Model of Porirua Inlet: comparison between the synthetic and real timeseries in Mana Marina shows a significant delay of more than 15 minutes, with the simulated waves being too late.

We hypothesise that the initial waves of the tsunami recorded in Mana Marina might result from another source located closer to Porirua than the currently proposed rupture models show. Doing an inverted tsunami travel time calculation, we estimate that the additional contributing source is located within Cook Strait, east of the Marlborough Sounds, being either the rupture of a fault that was previously missed or a submarine landslide. In either case, this suggests that the Kaikōura earthquake triggered a previously unrecognised tsunamigenic process well beyond the faults known to have ruptured coseismically.

New estimates of upper-plate faulting and folding accommodating tectonic shortening at the south-central Hikurangi margin, New Zealand

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Permanent deformation within the outer accretionary wedge of a subduction zone accounts for a large component of the tectonic strain budget and has important implications for understanding the elastic behaviour of the upper plate and megathrust. Permanent strain in the upper plate is partitioned between brittle and ductile processes such as faulting, folding and pore space compaction. The relative contributions of these processes to the total strain budget remain poorly constrained for the Hikurangi subduction margin and have not been fully quantified for subduction zones globally.

Here we draw on a revised structural interpretation and seismic stratigraphy of a seismic reflection profile (05CM-38) across the Hikurangi subduction zone to comprehensively revise previous estimates of shortening accommodated by faulting and folding within the upper plate. We analyse growth stratigraphy and apply a kinematic restoration workflow to reconstruct wedge evolution over the last ~1.5 Ma in the south-central region of the margin. Using MOVE software, major thrusts were restored using a trishear algorithm, complemented by estimates of incipient deformation from protothrusts measured within the trench region and extrapolated into the accreted wedge. We also apply a power-law relationship to estimate the shortening contribution of faulting at scales below seismic resolution.

Our results show that faulting accommodates more shortening than previously estimated for the Hikurangi subduction zone. Detailed restorations reveal temporal variations in the shortening rate over the last 1.5 Ma, that partly reflect periods of accelerated shortening through major thrust activations over relatively short time intervals and progressive seaward propagation of the wedge. These revised shortening estimates will be compared to along-strike variations in shortening to characterise broader subduction zone evolution.

Land-use influences on landslide-driven sediment generation and delivery across three major storm events in the Mangaheia catchment, Tairāwhiti

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Extreme rainfall events are primary agents of landscape change and sediment-related hazards in highly erodible, steep East Coast catchments, but the relative controls of storm magnitude, geology and land use on sediment generation and delivery remain poorly quantified. This study quantifies landslide-derived sediment generation and delivery to the Mangaheia River, Tolaga Bay, Tairāwhiti, across three major storm events: the 2018 Queen's Birthday Storm (June 2018), Cyclone Hale (January 2023) and Cyclone Gabrielle (February 2023). A total of 22,735 landslides were mapped across the Mangaheia catchment. The landslides were analysed using empirical methods and numerical modelling to estimate volumes of sediment generated and delivered to the drainage network. Cyclone Gabrielle produced the largest number and highest density of landslides, with combined estimated landslide source volumes of 1.03M m^3 (Gabrielle), 0.79M m^3 (Hale) and 0.97M m^3 (Queen's Birthday). Sediment delivery to channels was also greatest during Cyclone Gabrielle, with 0.63M m^3 (Gabrielle), 0.46M m^3 (Hale) and 0.31M m^3 (Queen's Birthday). Overall, 41% of sediment delivered to channels was derived directly from landslide source areas, with the remaining 59% entrained as landslides scoured soil and rock during transport to the channel network. Sediment delivery and connectivity increased with storm rainfall intensity but were also strongly controlled by rock type, erosion terrain, land cover and forest harvest history. Exotic forest and pasture contributed roughly equally to total sediment generation (53% and 47%, respectively), with most exotic forest landslides occurring in stands harvested 5–9 years before the storms, consistent with the post-harvest "window of vulnerability". Several significant failures also occurred on exotic forest slopes 10–15 years post-harvest, often associated with the failure of legacy forestry infrastructure. These results quantify how successive extreme storms, interacting with land-use history and geological setting, drive rapid landscape response and elevate sediment-related hazards in steep, erodible East Coast catchments.

The gallium-microbe association in siliceous hot springs

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Hot spring silica deposits from around the world highlight a strong association between the transition metal gallium (Ga) and microbial textures. This is best highlighted by cyanobacteria filaments which have up to ~50x enrichment in Ga within silicified microbial sheaths, compared to typical Ga concentrations in most geologic materials. We investigate the behaviour of Ga in three distinct geothermal settings; the Taupo Volcanic Zone (NZ), Yellowstone National Park (USA), and SW Iceland – using a range of bulk and in situ analytical techniques. In addition, microbial growth experiments, spiked with Si and Ga are utilised to eliminate complexity found in natural systems and focus on processes related to Ga enrichment. Results highlight both commonalities and distinctions across geothermal systems and between environmental conditions (fluid chemistry, pH, temperature, flow rates) pointing to a complex relationship between Ga and microbes. We suggest that Ga is a potential biosignature for examining ancient life in the deep time geologic record and that its complexation with Si is the key to unravelling the mechanisms for its significant enrichment in geothermal microbial material.

Characterising microseismicity across locking boundaries of the Hikurangi Subduction Zone:

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The Hikurangi Subduction Zone (HSZ) is New Zealand's largest plate boundary and source of earthquake and tsunami hazard. The extent to which the megathrust is locked or unlocked is a key control on the size and behaviour of future earthquakes, yet the offshore portions of these locking boundaries remain poorly constrained. Recent observations suggest that seismicity and slow-slip processes interact across these transitions, highlighting the need for improved observations of offshore earthquake activity.

This poster introduces a PhD project within a Marsden-funded research programme aimed at characterising the spatial and temporal distribution of microseismicity across the Trench-ward and Northern Locking Boundaries of the southern and central HSZ. The project forms part of a broader international, multi-disciplinary collaboration involving researchers from New Zealand, Canada, Japan and Germany, seeking to improve understanding of how slow and fast earthquake processes interact across locked and unlocked regions of subduction zones.

The study will initially focus on the year-long "Earthquakes and Locking inVEstigation of Subduction" (ELVES) ocean-bottom seismometer deployment, together with nearby onshore permanent GeoNet seismic stations. Additional "Processes UnderLying Slow Earthquakes" (PULSE) and "rePULSE" (re-installed PULSE) datasets will be incorporated as the project develops. Waveform-based automated seismic phase detection and association methods will be used to develop an enhanced earthquake catalogue, followed by earthquake location and relocation.

The resulting catalogue will provide improved constraints on the distribution, rates and characteristics of microseismicity around the locking boundaries. In later stages, focal mechanisms and stress inversions will be used to investigate faulting styles and stress conditions, providing further insight into the processes governing these transitions. Together, these analyses will contribute to understanding the relationship between slow-slip events, microseismicity and megathrust locking, with implications for earthquake and tsunami hazard along the Hikurangi margin.

Deep mantle structure suggests high temperatures and possibly rising mantle flow under northwestern New Zealand

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While the structure of the Hikurangi subduction zone and the Taupō Volcanic zone have been studied heavily, Northland has been the target of relatively few geophysical studies. Yet, new methodologies and instrumentation, including ocean bottom seismometers (OBS) and other temporary deployments, has recently brought insights into the deep Earth structure under northwestern New Zealand and the seafloor between Northland and Taranaki, where surface volcanism and hot springs are present. New Zealand-wide studies of receiver functions converted at mantle transition zone discontinuities point to low velocities at 410 km beneath and offshore Northland to the west. Surface waves from teleseismic earthquakes point to low velocities from the crust-mantle boundary to 100 to 150 km depth in this area. Likewise, conversions from shallower discontinuities at the lithosphere-asthenosphere boundary recorded at new temporary and permanent onshore stations in Northland suggest the low velocities and low resistivities reach up to 70 km beneath Auckland and 40 km beneath the Whangarei and Kaikohe-Bay of Islands Volcanic Fields. Lower resolution images from larger-scale P-wave tomography also suggest low velocities in these regions (Toyokuni and Zhao, 2024). These low velocities and low resistivities all suggest high temperatures beneath the Auckland and Northland volcanic fields, probably contributing melt to the volcanics. Finally, seismic anisotropy measurements from shear-wave splitting of mantle phases yield many “null” results through Hamilton and Auckland northwards. These null results suggest that mantle flow may be either near-vertical or chaotic. Near-vertical flow may be impinging from below on flow parallel to the subducting Hikurangi slab, causing a distinctive parabolic pattern. These can all be explained by hot material rising from depths, although the exact pattern and manner by which the material connects to the surface is not clear and modelling will be needed to test the hypotheses.

Enhancing indicator-based multidimensional landslide vulnerability assessment through people's perception

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Landslides cause impacts that extend beyond immediate physical damage, affecting people's wellbeing, social connections, cultural values, and institutional trust. Yet, landslide vulnerability assessment in New Zealand often prioritises physical and economic dimensions, with less attention to the sociocultural and institutional factors that shape overall vulnerability. Indicator-based methods (IBMs) operationalise multidimensional vulnerability assessment by selecting, weighting, and aggregating variables into composite indices across preparedness, response, and recovery phases.

However, reliance on secondary datasets, uniform indicators, and expert judgement can oversimplify complex social realities, leaving intangible and context-specific factors such as past experience, social networks, place attachments, and perceived institutional effectiveness poorly represented. Consequently, vulnerability indices may flatten contextual heterogeneity and inadequately reflect how at-risk communities experience vulnerability.

This study proposes an enhanced indicator-based multidimensional landslide vulnerability assessment that incorporates people's perspectives alongside measurable vulnerability indicators. The study will assess tangible and intangible sources of vulnerability to direct and indirect impacts of landslides across physical, social, economic, environmental, institutional, cultural, and psychological dimensions. Data will be collected across 14 selected suburbs of Wellington City through a door-to-door semi-structured questionnaire survey capturing residents' risk perception, preparedness, coping, and adaptive capacity across the above six dimensions. Respondents will rank the relative importance of vulnerability factors through pairwise comparisons, with these judgements converted into community-derived weights using the Analytic Hierarchy Process integrated with fuzzy logic to accommodate imprecision in perceived judgements. Focus group discussions and participatory mapping will contextualise indicators and identify locally meaningful factors.

The study will assess how people's perspectives can inform indicator selection and weighting in the development of a multidimensional vulnerability index. Rather than replacing quantitative indicators, the approach seeks to enhance their contextual relevance while retaining the comparability of indicator-based assessment, contributing to a more comprehensive and locally grounded assessment of landslide vulnerability in Aotearoa New Zealand.

Seismic-acoustic energy partitioning for mass-movement characterisation

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Mass movements, including debris flows, lahars, pyroclastic density currents (PDCs), snow avalanches, and landslides, are significant hazards to people and infrastructure. Effective hazard management requires reliable event detection and characterisation. Seismic and infrasound sensing provide continuous remote observations irrespective of visibility conditions; however, reliably distinguishing different mass-movement events remains challenging. This study investigates how the relative partitioning of seismic and acoustic energy could be used to simply characterise mass-movement events.

Twenty mass-movement events with publicly available seismic and infrasound observations were analysed. The seismic and acoustic energies were estimated from the recorded waveforms using a point-source model. Two different time-varying ratios were evaluated: a cumulative ratio and a sliding-window ratio, leading to the total and peak energy metrics used for characterisation.

Patterns in energy partitioning were observed between mass-movement event types. Dense flows, such as debris flows and lahars, generally exhibited the largest seismic-acoustic energy ratios, indicating a proportionally greater release of seismic energy. In contrast, lighter flows with suspended layers, such as powder snow avalanches, include the only event dominated by acoustic energy. Snow avalanches also exhibited the greatest variability within an event type, relating to the varying composition of avalanches from dense wet snow or ice avalanches to dry snow powder avalanches. Overall, the total energy ratio provided more consistent grouping of mass-movement types, while the peak energy ratio highlighted greater variability within event types.

Despite the limited dataset, these results demonstrate the potential of seismic-acoustic energy partitioning for remotely characterising mass-movement events. The total energy ratio appears better suited to broader characterisation of event types, while the peak energy ratio better highlights variability within event types.

The role of Geoheat in New Zealand's energy future

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Naturally occurring Geoheat resources are an opportunity waiting to be harvested for New Zealand. It is present across virtually all of the nation. The public in general and many professionals in the geothermal and the energy sectors are not aware or are overlooking the opportunities of low-temperature geothermal.

Decarbonising NZ's energy system is complex and costly, however using local energy resources reduces the need for capacity in the interconnected energy delivery systems.

Globally low temperature geothermal and geothermal heat pumps are the largest growth area for geothermal development, with Europe and North America having a long history of use, while China is quickly gaining momentum in the use of low-grade geoheat for process and commercial heat use. The impact that widespread deployment can have on reducing the electrical grid upgrading required is economically significant.

There is currently much discussion regarding geoheat in New Zealand, with the Governments National Geothermal Strategy highlighting it as key to doubling geothermal use by 2050. Recently, allocated Regional Infrastructure Funding is aimed at helping to understand these non-conventional geothermal systems.

New Zealand's horticulture industry are also investing in understanding the geoheat potential to support transitioning from fossil fuel heating (gas and coal). Work is underway to raise the awareness of using ambient and low temperature geothermal as the base energy source. Why burn gas when you only need energy supplied at 70°C.

Ambient and low temperature local geothermal resources can contribute now to reducing the system capacity growth required as part of NZ's decarbonisation. Residential heating and cooling networks can share subsurface infrastructure and resource, allowing efficient energy use, lower upfront and heating costing, resulting in healthier homes and populations.

This presentation will summarise current efforts in understand geoheat resource potential and its potential role in decarbonising NZ Energy system.

Geochemical advances associated with fracture-controlled fluid flow in hot dry rock (EGS) geothermal resources at Utah FORGE, SW Utah, USA

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Utah FORGE is a US DOE sponsored field laboratory for advancing geothermal energy technology in reservoirs hosted by hot dry crystalline rock. The facility centers on a drilled, stimulated EGS reservoir (200-225 °C, ~2.5 km depth) hosted by Oligocene-Miocene granitoid and Proterozoic gneiss that is associated with a large-scale magma-related geothermal system, which is divided into two distinct heat flow regimes. Convective heat flow predominates at Roosevelt Hot Springs 4 km to the east, whereas in the vicinity of Utah FORGE conductive heat flow predominates covering ~100 km^2; it is associated with very low natural permeability that mimics deeper conditions between 5 and 10 km depth. During stimulation involving high-pressure injection of cold-water, dilation of tight natural fractures dominated fluid flow path development, and flowback waters showed sharp increases in total dissolved solutes due to dissolution of highly soluble salts, confirmed much later when halite was identified along fractures in granitic rock in deep drill core. Additionally, oxygen and hydrogen isotope data from the initial flowback waters show strong enrichment suggesting vapor loss, despite high pressures suppressing two-phase conditions. Eventually, these effects were related to infiltration of supercritical CO_2 of upper mantle origin, first by noting weak acidification of injected waters during early circulation tests, and later by direct sampling and analysis of produced gases. Drawing on experience from CO_2 injection for enhanced oil recovery and sequestration, CO_2 infiltration is believed responsible for dry out and evaporation of injected waters, accounting for the stable isotope trends and salt deposition in fractures. These appear to be active processes associated with reservoir development, having also occurred in the geologic past. More broadly, they may account for the formation of carbonic brines in the crust, including in the vicinity of magmatic intrusions and in regions undergoing metamorphism.

Tūhono ngā Ākona ki te Pūtaiao Papa- Connecting Māori students to Earth Science

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Engaging Māori secondary school students in science requires approaches that are both culturally relevant and academically meaningful. Here, we present a successful outreach program that introduces Earth Science through hands-on demonstrations, storytelling, and mātauranga Māori, creating connections between scientific knowledge and Indigenous understandings of the natural world. Delivered in Kura Kaupapa Māori and other Māori educational settings, the program aims to inspire students to consider future pathways in Earth Science and related fields.

We provide an overview of the interactive demonstrations used to illustrate geological processes and materials, alongside traditional Māori uses of these, including the transport of fire using hollowed pumice filled with embers and sealed for safe carriage, and the use of obsidian as a highly effective tool for precision cutting.

A central feature of the programme is the integration of pūrākau involving atua and ancestral narratives. These stories provide cultural context for geological phenomena while strengthening students' connections to their whakapapa, landscapes, and histories. By weaving together mātauranga Māori and contemporary Earth Science, the programme demonstrates that Indigenous knowledge and scientific inquiry can complement one another in understanding the environment.

The approach seeks to increase student engagement, foster a sense of belonging within science disciplines, and challenge perceptions that science is disconnected from Māori identity. Preliminary observations suggest that students respond positively when scientific concepts are presented through culturally grounded examples that acknowledge both traditional knowledge systems and modern scientific perspectives. This model offers a pathway for enhancing Māori participation in Earth Science while promoting respect for multiple ways of knowing and understanding the Earth.

Insights into the volcanic-plutonic connection from glass-bearing plutonic clasts in the Ohakuri Ignimbrite, central Taupō Volcanic Zone

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The caldera eruptions of the central Taupō Volcanic Zone (TVZ) are inferred to be supplied by vertically extensive magma mush reservoirs. However, mush cannot be observed directly. To investigate the generation of rhyolitic magma under TVZ calderas, we characterise glass-bearing plutonic clasts erupted during the 240 ka Ohakuri eruption.

We present new textural descriptions of two types of glass-bearing clasts with whole-rock compositions and preliminary mineral and glass compositions. Most of the plutonic clasts are hornblende-bearing granophyric granite. Granophyric intergrowths are interstitial between large quartz and plagioclase crystals, suggesting that the granophyre crystallised rapidly from an interstitial melt during an undercooling event. The large crystals and granophyre are cross-cut by fractures that are infilled with rhyolitic glass, indicating a second episode of melt-generation and quenching during the Ohakuri eruption.

The second glass-bearing plutonic clast type are hornblende microgabbro. The whole-rock composition of the microgabbro clasts overlap with TVZ basalt compositions (SiO_2 ~51 wt.%). The clasts have ~10% interstitial, vesicular, microlite-free glass. The glass is rhyolitic (SiO_2 77.5 wt.%) and overlaps with Ohakuri pumice compositions. The textures and mineral compositions suggests equilibrium between plagioclase, hornblende, and the glass, implying that TVZ rhyolites could be generated by crystallisation of basaltic magma in a single step.

Glass-bearing plutonic clasts reveal a heterogenous mush system under Ohakuri caldera with multiple cooling episodes. These clasts are an important opportunity to study the processes of magma evolution and mobilisation in the build-up to eruption.

High resolution study of the complex effusive-explosive small-scale Ātiamuri eruption in the central Taupō Volcanic Zone

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Small dome-forming eruptions are the most common eruption style in the central Taupō Volcanic Zone, yet they remain relatively understudied compared to catastrophic caldera-forming eruptions. Here, we investigate the stratigraphy and petrology of the 229 ka Ātiamuri Formation, a small explosive-effusive eruption from the Maroa Volcanic Complex.

The Ātiamuri Formation outcrops over a ~5 km x 5 km area south of Lake Ātiamuri. It is composed of basal airfall deposits, followed by two pumiceous pyroclastic flow deposits that are weakly welded towards the top, an un-welded airfall deposit, a third pyroclastic flow deposit also weakly welded towards the top, and a top unwelded airfall deposit. All units have obsidian lithics. On the contact with Mandarin Dome there is a densely welded facies with glassy fiamme. We show pumice whole-rock compositions through the stratigraphy measured by XRF. SiO_2 decreases up the stratigraphy, the basal airfall have SiO_2 from 75.7 to 76.2 wt.% whilst the top airfall has SiO_2 from 74.6 to 75.0 wt.%. Trace element compositions are similar through the stratigraphy, suggesting a common magma source. Rhyolite-MELTS modelling suggests the major element trends are due to deepening of magma extraction from the mush through the eruption sequence from 237 to 267 MPa (9 to 10 km) to 319 to 323 MPa (~12 km).

The presence of two cooling units separated by airfall show that the Ātiamuri eruption had multiple eruption phases, with at least two climactic pyroclastic flow events. We suggest that Mandarin Dome was the vent of the explosive phases, and effusive activity followed the explosive phases. The example of the Ātiamuri eruption shows that dome-forming eruptions in the central TVZ can be complex events with eruptive styles varying from explosive to effusive activity.

Automated detection and characterisation of low-frequency seismicity as a window into volcanic processes in Aotearoa New Zealand

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Low-frequency (LF) seismicity provides an important window into the fluid and magmatic processes occurring within volcanic systems, yet these signals are often difficult to detect and characterise using conventional earthquake catalogues. Here, we will develop an automated workflow for detecting and characterising LF earthquakes and other volcanic seismic signals in continuous seismic data from selected volcanoes across Aotearoa New Zealand. The workflow combines deep-learning-based phase detection, automated phase association, and waveform-based classification to identify signals that may be overlooked by traditional monitoring approaches. Preliminary analysis demonstrates that EQTransformer, using the VolPick dataset, can identify several types of LF volcanic earthquakes previously observed during known unrest episodes at Ruapehu, Tongariro, and Whakaari. These initial results provide a basis for testing the workflow on continuous seismic data spanning approximately two decades, with the aim of identifying previously undetected LF seismicity and assessing temporal changes in its occurrence. We will also evaluate the performance of different pickers against other published deep-learning-based phase detection methods to determine their relative effectiveness for detecting volcanic LF signals. By applying and evaluating this framework across diverse volcanic environments, we aim to improve understanding of the distribution and characteristics of LF seismicity and its potential relationship to volcanic unrest and underlying magmatic processes. Ultimately, this work will contribute to developing a more comprehensive framework for detecting and characterising volcanic seismicity across the active volcanoes of Aotearoa New Zealand. The results presented here introduce the preliminary findings of the first chapter of my PhD, establishing the foundation for applying and refining this approach throughout the remainder of the research.

The Late Quaternary geometry and displacement of the Molesworth section of the Awatere Fault

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The dextral Awatere Fault is part of the Marlborough Fault System, which forms the Australian-Pacific plate boundary in the northern South Island. The Awatere Fault is 230 km long and ruptured during the 1848 Mw~7.5 Marlborough earthquake. We have studied the geometry and displacement history of the ~65 km long Molesworth section of the Awatere Fault using a recently released lidar DEM and existing dating of displaced landforms. The main fault trace varies in strike by up to 70° producing local structural depressions and pop-ups, with associated minor faulting. These tectonic fault traces are accompanied by extensive gravitational faults (e.g., ridge rents) in the ranges north of the fault. Landforms are displaced dextrally by up to 200 m and provide evidence for ongoing earthquakes with single event displacement of <4 m. The average slip rate of the Molesworth section since ~13 kyr is ~5.8 ± 1 mm/yr, with surface rupturing earthquake recurrence intervals of ~500-2500 years. Fresh fault scarps, a turf roll, small displacements (e.g., <3 m), and previous trenching shows that the last earthquake occurred in the last 450 years, consistent with the view that the 1848 Marlborough earthquake ruptured further west than previously proposed. This hypothesis and the paleoearthquake history are being tested by new trenches at Saxton River and Lake Sedgemere.

Building a facies framework to examine the type and distribution of organic matter in potential underground hydrogen storage site in the Taranaki Basin

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Interest in the use of sedimentary reservoirs for underground hydrogen storage (UHS) has been increased in response to issues with large volume storage of hydrogen gas. Hydrogen energy is important as part of the goal reducing reliance on fossil fuels in global energy sectors. Recent modelling studies for UHS in New Zealand have been focused on depleted hydrocarbon reservoirs within the Mangahewa Formation in the Taranaki Basin, which contain coal seams and variably organic rich sandstone and mudstone facies. However, hydrogen gas has the potential to react with organic matter (OM), which may lead to storage losses, and therefore understanding the type and distribution of OM within a potential storage reservoir is necessary to assess its suitability for hydrogen storage.

The sedimentary units within the Mangahewa Formation are characterised by lower coastal plain, marginal and shallow marine facies. OM type and preservation in these deposits is controlled by the source of OM (e.g. marine vs terrestrial), the degree of transportation and reworking by currents, and the exposure to oxygenation upon deposition. We have chosen three potential UHS storage sites in the Taranaki Basin from the Kapuni, McKee and Pohokura fields for studying the type, quantity and distribution of OM in facies with varying degrees of marine influence.

We present a sedimentary facies framework that examines the controls facies type has on the distribution and type of OM and how this may impact hydrogen storage within reservoir intervals containing these facies. Results from petrographic and total organic carbon (TOC) analyses of samples from cored sections of the late Eocene reservoirs will be used to characterise facies by OM types and concentrations using this framework.

Shifting sands

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Objectives: A striking geographical feature of Aotearoa's Northwest Coast are its iron-sand beaches. So much so that these are exploited commercially through mining at Port Waikato and Taharoa, with millions of tonnes of iron extracted annually. Return of iron-depleted sand occurs via the Waikato River, or directly into the ocean (at Taharoa) with changes in seabed and marine environments previously documented. Many organisms within the local marine environment are iron-dependent, and changes in iron homeostasis have impacts for the marine environment and for our climate through loss of carbon dioxide sequestration. This project aimed to evaluate iron (titanomagnetite) distribution along the northwest coast of Te-Ika-O-Maui to better understand the impacts of ironsand mining on the ecosystem.

Methods: This project collected >35 kilograms of sand across 7 beach sites (5 kg per site) from Raglan to Muriwai to map iron distribution patterns. Magnetic separation of sand into ferrous and non-ferrous portions was undertaken after oven-drying sand samples. Separated samples were weighed on digital scales and means, percentage iron concentration and site to site comparisons (ANOVA and post-hoc Tukey test) were used to evaluate for differences.
Results: Marked site to site variation in iron concentration was found, with iron concentration at Port Waikato 100% greater than in Piha or Muriwai ($p<0.000$). A gradient of decreasing iron content was identified moving north from Port Waikato, to Muriwai and an effect size of 66% was identified in relation to site location. Spatial variation of iron concentration was linked to weather patterns and hydrology.

Conclusions: A wide variation of titanomagnetite concentrations was seen moving northward from Port Waikato to Muriwai. Impact of iron removal is multileveled and further investigation and assessment is warranted to evaluate impact on marine life food webs and CO_2 sequestration.

Framework for assessing submarine volcanic hazards on the SW Pacific Tonga–Kermadec arc

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Along the boundary between the Australian and Pacific plates lies one of Earth's fastest subduction zones, the Tonga–Kermadec arc, the location of more than 80 submerged and emergent volcanoes. Hydrostatic pressure, geographic isolation, and circulation patterns challenge the observation and characterisation of submarine volcanic processes. Nevertheless, submarine eruptions can generate widespread hazards, such as tsunami, density currents, and pumice rafts, threatening marine environments, offshore infrastructure, and coastal communities.

Despite the global prevalence of submarine volcanism, it remains severely underrepresented in hazard assessments and monitoring, with no universal framework currently available to assess the relative threat posed by submarine volcanoes. The absence of a systematic framework for ranking submarine volcanic threat limits the ability to prioritise monitoring and research efforts to forecast the hazards from submarine volcanic eruptions. Adapting and modifying the principles of existing terrestrial volcanic threat ranking systems, we present a new Submarine Volcanic Threat Ranking System (SVTRS) for classifying the relative threat potential of submarine volcanoes along the Tonga–Kermadec arc to determine those that are most hazardous.

The SVTRS incorporates factors relating to historical observations, geomorphology, explosive and eruptive activity, and human and infrastructure exposure. Example factors include activity (indicated by hydrothermal venting or gas plumes), maximum slope angle, and summit depth. Each factor is weighted according to its relative contribution to volcanic threat and combined to derive an overall threat score for each volcano.

Initial development of the framework suggests that volcanoes characterised by shallow summits, large edifice volumes and histories of caldera collapse are likely to receive the highest threat scores. The SVTRS provides a structured approach for identifying volcanoes with the greatest potential threat and can be adapted to other submarine volcanic regions worldwide, supporting the prioritisation of research, monitoring, and hazard assessment efforts to better protect marine environments, infrastructure, and coastal communities.

A semi-restricted volcanic basin: evidence of deep-water isolation and exchange processes at Hunga volcano

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The ocean state around a submarine volcano provides information on circulation, biogeochemical cycling, and stratification. During the 2025 VEERI-H research voyage aboard the RV Investigator, we examined the environmental status of submarine volcano Hunga, three-years after the 15 January 2022 eruption. Twenty-two conductivity-temperature-depth (CTD) vertical water column profiles were collected inside and outside Hunga caldera, alongside 91 water samples collected at various depths. Samples were analysed for salinity, dissolved oxygen, nitrate, nitrite, phosphate, silicate, and ammonium concentrations. These data were combined with multibeam bathymetric data to investigate how the volcano geomorphology could influence the oceanographic processes that enable or limit water exchange within the caldera.

The majority of the rim of this shallow volcano sits at less than 100 m below sea level, with two breaches in the rim reaching 290 m and 185 m depth, connecting the caldera to the surrounding ocean.

Outside the caldera, CTD profiles show a well-mixed water column consistent with open-ocean conditions. In contrast, a highly stratified structure is observed within the caldera, where temperature, salinity, density, turbidity, and nutrient concentrations are distinct from those in the surrounding ocean. At depths ~850–900 m, waters inside the caldera are 13.7ºC warmer than outside, and at depths below 290 m, mean turbidity signal is 13 times higher than outside the caldera at similar water depths. Differing nutrient concentrations further distinguish the caldera water from the surrounding ocean.

These results describe the hydrographic conditions and water composition within Hunga's caldera compared to the surrounding ocean and demonstrate that geomorphology strongly influences water exchange following the 2022 eruption. The persistence of a distinct, stratified water body, combined with evidence of ongoing hydrothermal venting, provides insight into how submarine volcanic activity and geomorphology modify oceanographic conditions, biogeochemical cycling, and water column processes within and surrounding submarine volcanos.

Gallium as a biosignature: unlocking enrichment mechanisms

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Gallium enrichment is consistently observed to be closely associated with microbial life in multiple silica hot spring environments on Earth. This discovery has given rise to Ga as a prominent candidate for a potential geochemical biosignature in opaline silica, on account of the detection of opal-A silica deposits on Mars. However, it is currently unclear whether abiotic or biotic mechanisms support Ga enrichment in siliceous hot springs deposits, or sinter, with prior research suggesting the possibility for both. When considering a potential biosignature, petrography and geochemical techniques may help to refine the current plausible models to explain Ga enrichment. Paired sXRF and EPMA generated elemental maps and statistical tests were performed to elucidate the correlation between Si and C, with Ga. Together, these correlations aim to constrain gallium's relationship to biotic processes involving organic extracellular polymeric substances (EPS) which template silica, fundamental in constructing sinter.

Preliminary results indicate there is a clear spatial distribution of Ga, with an overall positive correlation between Ga concentration and Si X-ray intensity (proportional to concentration). However, C X-ray intensity displays a negative correlation to Ga enrichment. Consequently, when pairing the element ratio of Ga:Si versus C intensity, the correlation was weakly negative (Spearman correlation (rs) = -0.35, p = 0.023). Further statistical tests indicated a physical threshold, highlighting that the Ga:Si ratio shifts in behaviour at a low C intensity. Tentatively, these results suggest that Ga enrichment is tied to Si accumulation, in which an increased presence of organic matter seemingly acts as a physical buffer to Ga incorporation, reducing and keeping the Ga:Si ratio low and uniform.

Quantifying corrosion in volcanic ash and gas environments

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This project quantified the corrosion behaviour of common metallic building materials exposed to volcanic ash and gas, and their combined effects, with the aim of improving understanding of the durability of Aotearoa New Zealand's built environment in volcanic environments. The study combined one-year field exposure testing in the Rotorua Geothermal Field with laboratory characterisation to assess corrosion initiation, time-dependent corrosion behaviour, and material-specific responses.

Field testing was conducted at two sites in the Rotorua area with contrasting ambient gas concentrations. Five materials were investigated: carbon steel, copper, HDG, 55 wt.% Al-Zn alloy coating, and quartz zinc. Exposure conditions of gas-only, ash-only, and ash plus gas, were used to investigate interactions between ash and gas. In addition, two different volcanic ashes with contrasting properties were used. Materials were retrieved after ~1 week, 1 month, 3 months, and 12 months.

Corrosion was initiated rapidly under all exposure conditions. Carbon steel was the most-affected material, with the highest initial corrosion rates under combined ash and gas exposure. Copper showed strong sensitivity to volcanic gases but comparatively limited sensitivity to ash. HDG showed faster corrosion in the presence of ash, but this effect was short-lived. Al-Zn alloy coating and quartz zinc showed limited to no measurable deterioration under the exposure conditions tested.

A key finding is that the influence of volcanic ash was most important during the initial stage of exposure, because most ash deposits were washed from the test coupons by rainfall within the first few days. Even so, ash significantly accelerated corrosion of susceptible materials, particularly carbon steel and, to a lesser extent, HDG. These results indicate that post-eruption ash removal from vulnerable metallic building components is important for reducing corrosion risk, and that material selection is critical for improving resilience in volcanic and geothermal environments.

The structure and evolution of the Tarata Thrust Zone (Taranaki Basin, Aotearoa New Zealand)

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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. 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.

Results provide a 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. The geometry of the main thrust varies along strike, with areas of segmentation, and back-thrusting. The fault primary dips to the East and forms a detachment surface within the Mangahewa coal dominated unit. Faulting and folding are accommodated by 1.5 km of vertical displacement along the 65 km length of the fault.

Syn-tectonic sedimentary deposits show clear unconformities and thickness variations characteristic of thrust growth in the middle Manganui formation (c. Early Miocene). Between 18 and 16 Ma. This timing is approximately the same as the crustal shorting along the Hikurangi margin and in Marlborough, suggesting a period of plate boundary wide deformation, potentially associated with acceleration of plate convergence at this time.

Place, participation, and the co-design of school-based hazard education

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Natural hazard education is an important pathway for connecting geoscience knowledge with disaster preparedness and community resilience. Yet school-based outreach programmes can often be delivered as one-off engagements, with limited continuity or alignment with the needs, contexts and curricula of individual schools. This project explored how natural hazard education could be made more meaningful, engaging and sustainable through a participatory, place-based approach. We worked collaboratively with three Bay of Plenty schools to understand their contexts, needs, and priorities, and to co-design hazard education activities with teachers and students. Across the schools, engagement involved iterative hui with teachers, development and refinement of activities, and implementation with Year 7–8 students. Activities were tailored to local contexts. Three interconnected themes emerged as important for meaningful hazard education: where we learn, how we learn, and how learning is supported. Place-based learning connected hazard concepts to local environments, histories, cultures and identities. Hands-on activities, mapping, technology, storytelling and intergenerational learning provided diverse ways for students to engage with otherwise abstract geoscience concepts. Sustained teacher support, including accessible resources and pre- and post-engagement activities, was critical for moving beyond one-off outreach. The project demonstrates how geoscience outreach can contribute to disaster resilience when it is grounded in place, developed with communities, and supported over time. We argue for a shift from delivering hazard education to schools towards working with schools to develop locally relevant learning experiences that connect Earth processes, lived experience and resilience.

MLNZ20 magnitude scale operationalisation

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The MLNZ20 magnitude scale was defined for use in the 2022 National Seismic Hazard Model Revision with long-term applications as an Mw-approximate rapid magnitude scale with uses in event response and earthquake forecasting.

Operationalisation of the magnitude scale in GeoNet's SeisComP system is imminent but hinges on validation of the SeisComP implementation and a method to incorporate new stations into the scale.

In this poster we compare MLNZ20 magnitudes at network and station level between SeisComP and a reference catalogue to validate the SeisComP implementation.

We also introduce the method used to calculate corrections for new stations including analysis of correction convergence and stability and the effect new stations have on the performance of the magnitude scale.

Seismic data quality: probability of a phase pick using Earthquake Transformer

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Understanding data quality at seismic monitoring stations is essential for ensuring the network they form is fit for purpose. However seismic data are unique to their station and vary in nuanced ways which make comparison across stations or to general standards difficult. Quality metrics derived from earthquakes can bridge this gap but must overcome the diversity of source and path effects which also affect comparison across stations and to standards.

Seismic phase detection is a simple metric which can be directly compared across stations for earthquakes of a given magnitude and distance. In addition to working across the complexities of source-station distributions, phase detection probabilities are directly informative of station data quality as they are enhanced and suppressed by station quality factors like the sensor installation, site amplification and local noise.

Empirical phase picking information is available from the GeoNet earthquake catalogue, but this is inconsistent due to its origins in an operational earthquake localisation system with manual review.

To create a standardised catalogue of phase detections we use the deep learning phase picker EarthquakeTransformer to make phase detections on earthquakes in the GeoNet catalogue.

We use these detections to model the probability of phase detection for each station. By pooling the distribution of phase pick probabilities across the network we derive quality benchmarks against which station performance can be measured.

In addition to allowing relative station performance to be identified, our method also allows monitoring of station performance over time. Together these applications enable targeted network enhancements and remediations to secure the overall network capability.

Current implementation of this method uses a phase picker trained on the Southern California earthquake catalogue. Future work will look to develop a phase picker trained on an Aotearoa New Zealand AI-ready dataset to improve the accuracy and breadth of phase detections.

Short-term eruption forecasting using global monitoring data

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Short-term forecasting of volcanic eruptions relies on changes in monitoring signals such as seismicity, ground deformation, and gas emissions to infer the likelihood of eruption onset and potential eruption size. Nevertheless, the development of robust forecasting models is challenged by long recurrence intervals between eruptions and the limited duration of instrumented eruption records. In volcanology, data limitations such as these are often addressed by using observations from analogous systems. However, precursory activity is not uniform between volcanoes; for example, a modest increase in earthquake counts may precede eruption at one volcano, whereas a much larger increase may be considered unrest at another. Monitoring system setup is also highly variable between volcanoes.

To address this, we applied a novel approach utilising qualitative monitoring information reported in the Smithsonian Global Volcanism Program (GVP) Bulletin Reports. Inclusion in the GVP reports was used as a means of normalizing volcanic unrest across diverse settings under the assumption that conditions reported in a bulletin represent activity considered anomalous relative to the baseline behaviour of that volcano. Our growing dataset currently consists of 167 monitored eruptions at 12 volcanoes. Using this unique dataset we trained random forest classifiers to forecast eruption onset and eruption size. Models performed well, with macro F1 scores of > 0.65 for both tasks (1 is the best possible performance). Results show that our approach is a promising means of incorporating information from analogous systems into short-term eruption forecasts offering a potential pathway towards a transferrable method for eruption forecasts at volcanoes, particularly those with limited instrumented eruption records.

Why collections matter

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Species Aotearoa is a collaborative network of researchers and collection managers from New Zealand institutions responsible for natural history collections and taxonomic and systematic research. Established in response to the Royal Society Te Apārangi 2015 review of taxonomic collections, the network works to strengthen connections among collections, researchers, tangata whenua, government agencies, industry, communities, and international partners. It aims to coordinate the implementation of priorities identified in national collection strategies and to promote the critical role of taxonomy and biosystematics in supporting science, conservation, policy, industry and society.

A key focus of Species Aotearoa is to raise awareness of the enduring value of natural history collections as nationally significant research infrastructure. These collections underpin biodiversity discovery and monitoring, environmental management, biosecurity, conservation planning, cultural knowledge, and scientific innovation. The network advocates for sustained investment in collections, recognising that their long-term value depends on ongoing care, accessibility, and development.

To support these goals, Species Aotearoa is developing several community-wide initiatives that highlight both the opportunities and challenges facing natural history collections, including the need for best-practice collection management, enhanced digital infrastructure and data integration, and a skilled curatorial and taxonomic workforce. By bringing multi-stakeholder insights together and demonstrating the broad impact of collections, the network aims to strengthen support for their future and ensure taxonomic collections continue to benefit generations to come.

Using AI in geosciences: review of a few case studies

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The past few years have seen the development and popularisation of artificial intelligence (AI) and deep learning approach used to automatically recognise datasets of micropaleontological images. Such approaches are now routinely used to detect and recognise images of microscopic objects in research institutes, allowing to save a substantial amount of time when several hundreds of specimens typically have to be manually counted over hundreds of samples by a human operator, while some morphometric analysis of microscopic object would simply not be feasible in a reasonable amount of time.

Various groups of microfossils have been investigated so far using deep learning techniques, including coccoliths, foraminifera, radiolaria, silicoflagellates, diatoms, and pollen grains, to cite a few. Here, we will present three examples of paleo-environmental reconstructions and case studies associated with automated recognition and morphometric measurement of three different groups.

The first application focussed on the silicification response of plankton to global climate variability from both the low and high latitudes of the Northern and Southern hemispheres and for the last 63 million years using automated recognition and measurement of more than 400,000 radiolarian specimens. The second case study shows a spatio-temporal reconstruction of the Eastern North Pacific oxygen minimum zone for the past 55 thousand years, based on a transfer function using benthic foraminifera that were either manually or automatically (67,000 specimens) identified. Finally, the third application is the development of marine diatoms recognition using object detection for Antarctic biostratigraphy on field past sea ice and icesheets variability.

A recognition-assisted camera for automated microscopy (RaCAM) applied to geoscience studies.

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Automated microscopy workflows, including image acquisition, processing, and recognition using artificial intelligence (AI) are getting a growing interest from the scientific community in biogeosciences, as more and more research institutes are actively working on building datasets of images to train artificial convolutional neural networks (CNNs) to identify microscopic objects for example.

Here, we present a new, affordable, AI-assisted, and open-source camera, that can fit any microscope equipped with a regular C-mount (or CS-mount) camera thread. This camera is equipped with an integrated Single-Board Computer (Raspberry Pi 5) and high-resolution camera sensor (12.3 mp), attached together using a 3D-printable adaptor. Using two new open-source workflows written using the Python language, and freely downloadable too, the camera is capable of performing automated microscopy using either an automated image segmentation workflow (RaCAM_IS software, including image acquisition, and automated image processing and object recognition using trained ResNet50 CNN models), or an object detection workflow (RaCAM_OD software including image acquisition and automated still image / live stream object detection using YOLO models).

Pseudodynamic modeling of multifault ruptures: the 2016 Mw 7.8 Kaikoura Earthquake

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A pseudodynamic approach to earthquake-rupture modelling aims to generate physically consistent kinematic parameters while emulating key spatiotemporal characteristics of dynamic ruptures. The 2016 Mw 7.8 Kaikōura earthquake provides an opportunity to evaluate such an approach for complex multi-fault ruptures. We investigate a dynamic rupture model of the event and find that slip tapers towards rupture terminations but not at fault intersections, whereas rupture velocity shows no systematic tapering but decreases when rupture transfers to differently oriented fault segments. Across the fault segments, average slip is generally larger and average rise time shorter than predicted by published scaling relations. However, slowly rupturing segments (0.5–0.9 km/s) exhibit very low slip (<0.1 m) and longer rise times. The kinematic parameters are otherwise weakly correlated, except for positive correlation between slip and peak slip rate and negative correlation between rise time and rupture-onset time. These statistical characteristics underpin a pseudodynamic rupture model for the event.

Characterising seasonally variable exogenic controls on carbon dioxide surface flux at Rotoiti, Ōkataina Volcanic Centre, New Zealand

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Volcanic lakes overlying magmatic-hydrothermal systems variably store and release gases emitted into lake waters. Seasonal thermal stratification may temporarily trap dissolved CO_2 within the cold hypolimnion, such that surface CO_2 flux measurements may not accurately represent the rate of magmatic-hydrothermal CO_2 emission from the lake floor. Lakes cover ~20% of the Ōkataina Volcanic Centre, yet their magmatic-hydrothermal CO_2 emissions remain poorly constrained due to sparse flux measurements. Rotoiti, a monomictic lake on the northwestern caldera margin, overlies the Tikitere-Taheke hydrothermal system, and it's uncertain whether the lake's annual CO_2 emission is represented by the only published estimate (271 ± 38 t d^{-1} CO_2), derived solely from peak-winter floating accumulation-chamber (FAC) measurements in August 2020. To evaluate seasonal variability, repeated lake-surface CO_2 flux measurements were conducted across the lake's Central Basin, Haupara and Tumoana Bay using a West-Systems FAC coupled to an Li-820 NDIR gas analyser. Flux measurements were obtained during thermally stratified (January-April 2026; n=73) and overturned conditions (June-July 2026; n=139). Simultaneously, Soil CO_2 efflux was measured to assess whether lacustrine dynamics reflect broader terrestrial degassing mechanisms. Preliminary observations show median flux increased from 6.6 (IQR: 5.0-7.9) to 12.6 (8.8-17.8) g m^{-2} d^{-1} as summer stratification transitioned to winter overturn. Detectable flux within our measurement area expanded from 18% to 88%. Notably, a single Central Basin flux measurement (~351 g m^{-2} d^{-1}; January) reflects localised venting, skewing the mean ± SD. Conversely, median soil flux decreased from 31.8 to 22.6 g m^{-2} d^{-1} (IQR: 24.7-41.0 and 16.6-25.7, respectively), indicating diminishing soil-gas permeability as rainwater fills pores and restricts terrestrial degassing. This divergence supports exogenic controls on lacustrine degassing, whereby gas retained beneath the thermocline is released during overturn. While lake-wide emission estimates require further measurements, these results emphasise the need for seasonal baselines to assess CO_2 degassing in volcanic lakes.

An update on mapping the Auckland Volcanic Field

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Recent geological mapping in the central Auckland area has for the first time separated each volcano of the Auckland Volcanic Field into distinct sources and mapped related eruption products. Member status within the Auckland Basalts Formation is proposed for each volcano, with names following the traditional Māori usage. Combined geological and geomorphological mapping has utilised lidar data, historic aerial photographs and other published material to aid definition of the natural footprints of the volcanoes. We also draw upon a full new geomorphic interpretation, highlighting and categorising with overprints the complex anthropogenic landscape changes that have occurred within Aotearoa New Zealand's largest city.

Sub-surface bore hole information has been widely consulted, particularly in areas where urbanisation has modified or obscured the ground surface. The latest available dating has been incorporated into the map and accompanying legend, which provides a powerful tool to visualise the evolution of the volcanic field over its ~200,000-year lifetime. Some highlights of the new mapping include identifying where the breached part of Ohinerangi/Mount Hobson scoria cone ended up, recognising a previously unmapped lava flow on the south side of Puketapapa/Mount Roskill cone, and finding a small tuff ring east of the airport – Auckland's 54th volcano. The map will be published as a PDF at 1:35,000 scale, along with the legend, and digital data will be available through various GIS web applications.

The Dunstan Fault, Central Otago: which trace will rupture next?

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The Dunstan Fault is a slow slip rate reverse fault within the Otago Fault System, South Island, New Zealand. It is expressed at the surface by multiple parallel to sub-parallel traces spanning a ≤2.5km fault zone width. On the Devonshire Alluvial Fan, the Dunstan Fault is expressed along four major fault traces: D1, M2, D2 and D3 (Van Dissen et al., 2007). Paleoseismic trenches, excavated as part of this study, across D1, M2 and D3, provide evidence for 3, 2 and 1 earthquakes, respectively. Previous paleoseismic work on the D2 trace provides evidence for 4-6 earthquakes (Van Dissen et al., 2007). If all earthquakes are assumed to have ruptured independently, there is evidence for at least 10-12 earthquakes on the Devonshire Fan. Optically stimulated luminescence dating of key stratigraphic horizons was used to confine earthquake timing and better understand the spatial-temporal pattern of earthquake ruptures across the deformation zone width. Analysis of these ages, along with the earthquake chronology from the D2 trace (Van Dissen et al., 2007), yield some interesting results: (1) The most recent earthquake on the Dunstan Fault occurred within the past 1,900 years, far earlier than previously estimated (8,830 – 14,400 yrs; Van Dissen et al., 2007); (2) There have been at least 5 ground rupturing earthquakes within the past 12,600 years; (3) The three most recent earthquakes on the Dunstan Fault appear to have ruptured individual fault traces only, providing evidence to suggest that traces on the Dunstan Fault do not rupture together; (4) The two most recent earthquakes appear to have ruptured the antithetic trace only, providing insights into the possible subsurface fault geometries which could kinematically allow such rupture. These findings have enhanced our understanding of the multi-trace behaviour of the Dunstan Fault, and better our understanding of reverse fault displacement more generally.

Baseline CO_2 diffuse degassing and heat flux budgets for Paka geothermal field using ground- and remote-sensed measurements

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Although geothermal systems play an important role in global natural CO_2 emissions, the impact of geothermal power production CO_2 emissions is poorly studied and may vary substantially among different types of geothermal fields. Both increasing and decreasing trends in soil CO_2 diffuse degassing associated with geothermal exploitation have been inferred for several fields worldwide. However, studies incorporating comprehensive assessments of pre-production conditions are scarce, making it difficult to distinguish between natural and anthropogenic changes. The Paka geothermal field, located in Kenya, provides an ideal setting for a detailed assessment of baseline CO_2 diffuse emissions and heat flux budgets prior to exploitation. In this study, remote-sensing data were used to optimise the efficiency of ground-based measurement campaigns. In total, 1,299 CO_2 flux measurements and 1,297 soil temperature measurements were collected using the accumulation chamber technique with a PP Systems EGM-5 portable gas analyser and a thermocouple inserted to a depth of 15 cm, respectively. Thermal infrared data were also acquired using a DJI Mavic 3T drone. Our results demonstrate a correlation between structural fabrics and the two-dimensional spatial distribution of CO_2 and heat fluxes. Primary statistical parameters were quantified using graphical statistical analysis and sequential Gaussian simulation. Furthermore, the relationship between CO_2 flux and soil temperature was utilised to estimate total soil CO_2 diffuse degassing from remotely sensed data. Finally, drone-derived total flux estimates were compared with budgets computed using geostatistical approaches. We highlight the importance of conducting pre-production CO2 flux studies at developing geothermal fields to establish robust baseline estimates of diffuse CO_2 degassing and heat fluxes. Such assessments are crucial for geothermal companies to better understand and quantify their environmental impacts of resource development, particularly in light of the increasing financial incentives and investments directed towards current and future green energy projects.

75 years of Rafter Radiocarbon Laboratory data

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Rafter Radiocarbon Laboratory made our first radiocarbon measurements in 1951. Over the following 75 years, our measurements have evolved from the earliest solid carbon measurements to the gas counting technique to today's accelerator mass spectrometry (AMS). Pretreatment to isolate specific carbon fractions and remove contaminants has continuously advanced, now allowing dating of individual compounds and compound classes. Enhanced graphitisation and measurement capabilities have enabled the analysis of progressively smaller sample sizes necessitated by upgraded pretreatment methods, such that we now routinely measure samples of 150 µg carbon and can measure samples down to 10 µg carbon. Measurement precision has likewise improved to a repeatability of 1.3‰ (10 years) for some sample types.

These results continue to be widely used in new analyses, expanding datasets with new measurements, and augmenting ongoing time series. To facilitate these applications, we have digitised the gas counting records from 1951-1995 and made them freely available through the ESNZ data portal (www.gns.cri.nz/data-and-resources/). Early results were reported before radiocarbon conventions existed, and we have recalculated the Conventional Radiocarbon Age and Fraction Modern from the original measurements with respect to the current reporting conventions, sometimes changing the reported age by several hundred years. The current publication includes 7,000 of the 9,000 gas counting records and we are working through the original handwritten notes and will regularly update the published dataset. We plan to publish the first 25 years of AMS data (1987-2012) in 2027. Unpublished data can still be accessed by contacting us. In this presentation, we will discuss the data and access to it and highlight some of the most interesting historic results.

The crustal structure of the Auckland Volcanic Field

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The Auckland Volcanic Field (AVF) is an active distributed volcanic field sitting on top of the largest city in Aotearoa, New Zealand. The origin of the field is poorly understood, and the topic of a large international project. In this presentation, we will provide an update on detailed crustal imaging with ambient noise surface-wave tomography and shallow P- and S-wave tomography. These studies are based on an extended Geonet network of seismometers plus a temporary array of land stations. The resulting models provide the greatest detail on crustal structure of the AVF to date, including information on the 3-dimensional extent of the geologic terranes and (active) faulting that may impact melt pathways to the surface in Auckland. In future work, the details of the crustal structure will support deeper modelling efforts deep into the mantle from where it is believed the AVF melts initiate.

Natural hazard risk perception and preparedness in a multi-hazard environment

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Aotearoa New Zealand, like most countries, can experience multiple different types of natural hazard events. Often these coincide (two or more unrelated events occurring at the same time), cascade (one event causes one or more other events), or compound (one event is made worse by another event). However, research exploring risk perception and individual preparation typically focuses on a single hazard. Similarly, public education campaigns often address either a single specific hazard or emergencies generally.

This presentation will cover the reasons why multi-hazard considerations within research is vital, the challenges (and benefits) of doing so, and evidence from New Zealand demonstrating how non-experts perceive risks differently within multi-hazard contexts. Implications for public education efforts in particular will be discussed, such as promoting preparation actions for impacts (e.g., loss of power) rather than specific events (e.g., an earthquake).

Whitford Geothermal System, Auckland: evidence for extension into Flat Bush

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The Whitford geothermal system is one of the least studied low-temperature geothermal occurrences in the Auckland region. Historically identified through the accidental discovery of warm groundwater and with no surface expression, the system occurs within a structurally complex setting influenced by the tectonics of the Hauraki Rift and its associated fault networks. Despite its proximity to rapidly developing urban areas, the extent and controls of the geothermal system remain poorly constrained.

This study integrates the limited available groundwater temperature data and subsurface stratigraphic information to reassess the distribution of geothermal fluids in the Whitford area and evaluate whether the system extends beneath neighbouring Flat Bush. Spatial trends in groundwater temperatures, together with structural interpretations derived from existing geoscientific datasets, suggest that geothermal circulation may extend beyond the established area at Brownhill Road. Several temperature anomalies identified in the Flat Bush area are consistent with the presence of fault-controlled fluid pathways linking the two areas.

The conceptual geological model developed indicates that basement fault structures provide potential pathways for the transport of warm groundwater. These findings imply a larger geothermal footprint than previously recognised and have implications for understanding local heat flow, groundwater circulation, and the management of geothermal resources within Auckland's expanding urban environment.

The results highlight the need for further targeted temperature logging, groundwater sampling, and geophysical investigations to better define the transport pathways and demonstrates the potential of near field exploration for low-temperature geothermal systems in Auckland.

GHA Assistant: an AI agent for real-time information-gathering during geohazard response

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During an active geohazard event, Geohazard Analysts at the NGMC must rapidly gather and synthesise information from multiple sources under significant time pressure, often while simultaneously managing other monitoring tools and communications. Reducing the manual burden of this information gathering step, without compromising reliability or auditability, is key to freeing analyst attention and energy on the more critical steps.

Here, we present a GHA Assistant developed by Geohazard Analysts (GHA) with our AI Advanced Analytics team to streamline information gathering, situational awareness, and decision support during geohazard response.

We then discuss the design trade-offs involved in building trustworthy, human-in-the-loop automation and AI systems for operational geohazard monitoring which particular emphasis on reliability, auditability and analyst trust.

Rapid analysis of volcanic plume height eruption source parameter using fixed cameras

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Explosive volcanic eruptions can generate plumes which transport volcanic ash up into the atmosphere, at which point it is dispersed by atmospheric winds. This ash, and the associated ground-level fallout, can be harmful to human and animal health, disrupt transport and other critical infrastructure and incur significant clean-up costs. Atmospheric dispersion models can be used to forecast where the ash will go and when it will arrive. However, reliable forecasts depend on knowledge of eruption source parameters including, primarily, the height of the volcanic plume. Fixed webcams are frequently used as part of operational volcano monitoring networks and provide a potential source of information on volcanic plume height. However, in order to extract quantitative information on plume heights, a calibration relating pixel position to physical locations is required. Here, we present a geometric calibration of GeoNet's volcano webcam network which accounts for camera properties and incorporates a correction for wind-bending of the volcanic plume through the use of updated wind forecast data. Our work has led to the creation of a newly developed dashboard that could support eruption responses. Finally, this presentation discusses the advantages and limitations of our tool, as well as presents possible future developments.

SEAFAULT: seismic imaging of active fault connectivity and segmentation across Cook Strait, Aotearoa New Zealand

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Cook Strait is located in a complex tectonic transition zone between Aotearoa New Zealand's North and South islands, where the Hikurangi subduction margin, Marlborough Fault System, and other active upper-plate faults interact. Understanding the geometry, segmentation, and connectivity of these structures is critical for constraining earthquake and tsunami hazards. However, the structural configuration of active faults across Cook Strait remains debated. Previous high-resolution seismic mapping (<100 m subsurface depth) has identified fault terminations, lateral step-overs, and regional changes in strike, suggesting substantial segmentation of offshore fault systems. In contrast, interpretations based on historical earthquake observations and deeper-penetrating seismic data (>1 km depth) have proposed broader seismogenic zones and possible connections between major faults at depth. Resolving these contrasting models requires improved imaging of fault structures beneath central Cook Strait.

Although high-resolution seismic coverage is relatively extensive across the Marlborough shelf, a major gap in subsurface imaging remains across central Cook Strait. To address this, the recent research voyage TAN2505 acquired an extensive grid of 2D multichannel seismic reflection profiles together with high-resolution sub-bottom profiler data. Here, we combine these new observations with legacy seismic datasets to systematically interpret structural and stratigraphic relationships across the region. We present the processing workflow developed to improve subsurface imaging, together with preliminary results from fault mapping and seismic-stratigraphic interpretation. Initial results indicate greater structural continuity between fault systems across Cook Strait than suggested by previous near-surface interpretations, while also revealing important variations in fault geometry and segmentation. These results provide new constraints on the three-dimensional architecture of the Cook Strait fault network and will contribute to future revisions of the New Zealand Community Fault Model and associated seismic hazard assessments.

Daily seabed mobility from repeat multibeam surveys in Cook Strait/Te Moana o Raukawakawa

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Cook Strait/Te Moana o Raukawakawa is known globally for its vigorous tidal flows, ocean waves and winds, and dynamic seabed environment. This narrow passage of water is also the primary connection between Aotearoa New Zealand's main islands, hosting a busy shipping passage and subsea cables (i.e., HVDC Inter-Island link). During a multibeam hydrographic survey in 2017, a unique helical network of gravel bedforms on the continental shelf (~50-100 m water depth) was revealed for the first time. These bedforms were subsequently resurveyed using the same multibeam system in 2020 and 2021, documenting morphological changes to plan-view dune geometry and bifurcation of crestlines over annual timescales. Modelling suggests that average hydrodynamic conditions in Cook Strait are capable of mobilising coarse-grained seabed substrate (i.e., sand to gravel), indicating that the observed morphological changes could be a snapshot of continuous incremental modification, rather than only during infrequent, high-magnitude events.

In 2023, a rare data co-collection opportunity arose to resurvey this set of extraordinary bedforms seven times over at near-daily intervals to assess high-frequency morphological changes. These novel remapping campaigns spanned a range of tidal conditions (e.g., flood, ebb and slack) and included coincident water-column measurements, including multibeam backscatter, ADCP velocity, direction and turbulence. Initial results indicate that the gravel waves are highly dynamic over the week-long survey, with vertical changes of up to 1.5 m and horizontal shifts up to 15 m. The maximum observed change between 3–5 August coincided with the 2nd largest spring tide of the year. This study provides the first high-frequency multibeam dataset documenting daily seabed change in Aotearoa New Zealand. Unravelling the frequency, variability, magnitude and mechanisms driving bedform change has implications for ocean dynamics and marine habitats. In addition, this location is of high importance for present and future seafloor and near-bed infrastructure.

Today's mine, tomorrow's heritage

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Mining is an activity that can have lasting effects on landscapes and surrounding communities. Historically, mining has often given little consideration to its long term cultural and environmental legacy. Fortunately, this attitude is changing. In New Zealand today, the post-operational environmental and cultural legacy of a mine is central to decision making throughout a mine's operation.

This presentation explores how mine sites can contribute to and become part of the broader heritage landscape of a region.

In New Zealand, all active mines are situated within historically mined regions. This coexistence of old and new presents challenges but also creates valuable opportunities. One such example is OceanaGold's Macraes Operation, where historic buildings, mine shafts, and old equipment exist right next to the active mine. This allows visitors to experience the contrast between past and present in an accessible and hands-on way.

An example of a modern, recently closed mine which is moving into the "Legacy" category is the Globe Progress Mine near Reefton, South Island. Following the mine's closure, extensive environmental remediation and revegetation work has been carried out together with the construction of recreational paths, setting up of information panels, and display of old mining equipment. The restoration project at Globe Progress is a great example of how a former mine site can become/ remain a community asset, providing value long after mineral extraction has ceased. By reflecting on both operational and closed mine sites, it is apparent that the legacy of a mine site is not decided at the end of operations but throughout its operation.

Southern Ocean microfossils: an archive of micronutrient availability through the Last Deglaciation

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The Southern Ocean is a pivotal component of Earth's climate system, acting as a major sink for atmospheric carbon dioxide and regulating the exchange of heat, nutrients, and gases. In the longer term, this capacity for carbon sequestration is largely driven by marine productivity, which depends on the availability of micronutrients such as iron, zinc and cadmium which are essential for plankton growth. However, the response of Southern Ocean micronutrient cycling to past climate change remains poorly understood. The Last Deglaciation (18-12 ka), a period of rapid warming and global climate reorganization, provides a valuable analogue for projecting these responses into the future.

This study aims to reconstruct past seawater micronutrient variability by investigating the iron, zinc and cadmium concentrations in planktonic foraminifera shells preserved in ODP core 1170A, situated on the South Tasman Rise. Site 1170A is currently located within the Subantarctic Zone and is particularly sensitive to latitudinal shifts in major oceanic fronts and associated changes in water mass properties and nutrient supply during glacial/interglacial transitions. Foraminifera can provide high-resolution archives of past seawater chemistry because they incorporate trace elements from the surrounding seawater into their calcite shells during growth. By analysing the trace metal concentrations of preserved shells from individual species of foraminifera representing habitats from the surface ocean to the thermocline, micronutrient variability across the upper to mid-depth water column through the last deglaciation can be reconstructed.

These reconstructions will be used to evaluate how changes in micronutrient availability relate to shifts in ocean circulation, water mass structure, nutrient supply and primary productivity during the Last Deglaciation and beyond. The results will provide new insights into the role of micronutrient cycling in regulating the Southern Ocean biological carbon pump and improve our understanding of how this key region may respond to ongoing climate change.

National 3D facies dataset for New Zealand groundwater assessments: progress and application

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New Zealand has published 2D maps on the boundaries of groundwater systems and surface geology with milestones including maps at the national scale of: aquifers; surface geology in a digital dataset ('QMAP'); and hydrogeological system classifications.

From 2019, a national 3D facies digital dataset has advanced that aims to capture an up-to-date understanding of New Zealand's aquifers in a cell-based model that classifies: facies (generally, a proxy for aquifer properties), geological age and hydrogeological system type. Model developments have produced 2D and 2.5D digital facies maps, and 3D facies models, that are relevant to groundwater investigations at multiple scales. 3D model cell dimensions varied with unit age, e.g., cells in Quaternary coastal systems were generally 100 m by 100 m (i.e., in the x, y and z directions), resulting in large datasets at national and regional scales.

This paper provides an update to the development of the 3D facies dataset, e.g., with facies models of New Zealand hydrogeological systems. In the last year, we completed the national 3D facies dataset for all New Zealand's coastal systems. This facies dataset renders, in 3D, key aquifers and aquicludes. This year, we also developed a facies nomenclature for basement units.

The paper will demonstrate the national-scale and regional-scale models and summarise some applications of the 3D datasets to groundwater resource assessments. Studies, completed and on-going, have included: climate change (Marlborough, Southland and Canterbury), and shallow groundwater flow (Auckland and Christchurch). Local groundwater resource availability and drilling prospectivity were assessed (Wellington and Pukekohe).

National 3D facies model for New Zealand: application to shallow groundwater hazard forecasting in the Auckland isthmus

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A New Zealand national 3D facies digital dataset aims to capture an up-to-date understanding of New Zealand's aquifers in a cell-based model with: facies (generally, a proxy for aquifer properties), geological age, hydrogeological system type, and the like. The facies dataset began with 2D digital maps at the national scale, e.g., geology ('QMAP') that classified hydrogeological boundaries, including coastal groundwater systems.

The datasets include 2D facies maps and 3D facies models. The 2.5 D 'Hydrogeological Unit Map' (HUM) summarised many hydrogeological units (e.g., aquifers and aquicludes) and their facies (e.g., braidplain gravels and volcanic units). Facies were assigned to 3D model cells with several approaches. For example, 3D facies were calculated with Boolean operators that were trained on well logs supplied by regional councils. Cell dimensions varied with unit age, e.g., cells in Quaternary units were 100 m by 100 m by 1 m (i.e., in the x, y and z directions, respectively).

This paper provides an update to the development of the 3D national facies model dataset in180 (approximately) New Zealand coastal systems; 45 separate facies were identified in the model.

The 3D facies model was used as part of the identification of urban groundwater catchments and drainage networks in the Auckland isthmus that may be subject to flooding (surface and groundwater) for 'long' periods and may require diversion, or pumping, to assist with flood recession.

Unconfined aquifers intersected by screened wells, and catchment boundaries, were identified by the 3D model. Time-series groundwater level data were then used to develop preliminary groundwater level forecasting models. Forecast potentiometric surfaces, and a DEM, identified locations of groundwater-related flooding or delayed flood recession beyond the period of surface-water flooding. The operational implications of this analysis will be presented.

A catalog of Slow Slip Events at the Hikurangi Subduction Margin from 2006 to 2016

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Slow slip events (SSEs) are frequent along the Hikurangi Margin and understanding them is critical to our understanding of interseismic coupling, plate motion budgets, and the potential for damaging earthquakes. Deeper and less frequent SSEs are observed on the southern margin, while shallower and more frequent events are observed along the northern section. We have compiled a catalogue of Hikurangi SSEs from 2006 to 2016 to help us understand the spatial and temporal patterns of slip. This allows us to characterise the behaviour of Hikurangi SSEs, looking at properties such as depth, peak slip rate, total slip, and recurrence interval. It also allows us to explore scaling relationships.

We use the Network Inversion Filter (NIF) [Segall and Matthews,1997; McGuire and Segall, 2003; Miyazaki et al., 2006] to perform time-dependent slip inversions. We generate Green's functions using the PyLith finite element code [Aagaard et al., 2013] to include elastic property variations provided by the New Zealand-wide seismic velocity model [Eberhart-Phillips et al., 2010]. Previous results [Williams and Wallace, 2015; 2018] showed that SSE inversions that consider elastic heterogeneity provide significantly different results compared to elastic half-space solutions. Incorporating these effects significantly improves the accuracy and reliability of our time-dependent inversions. Most recently, we have used the VDoHS technique [Haines et al., 2015] to provide cleaner time series as input.

We have developed an automated technique for extracting SSE events from our inversion results to create a catalogue. In an initial analysis, we find log(moment) to be proportional to powers of ~2.9 for area and ~2.0 for duration. A regular earthquake would have an exponent of 1.5 for area and an expanding circular crack in an unbounded domain would yield a power of 3 for duration. These differences may be due to the relative complexity of the SSEs compared to regular earthquakes.

Earthquake triggering in the North Island of New Zealand following the Kaikōura Earthquake.

Codee-Leigh Williams[1], Calum Chamberlain[1], John Townend[1]
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Changes in seismicity rates in response to passing seismic waves can provide key insights into variations in stresses on faults at depth. Above the Southern Hikurangi Margin, crustal faulting plays a key role in generating large magnitude events (e.g. 2013 Cook Strait and 2016 Kaikōura earthquakes). Despite this, little is known about how these crustal fault systems respond to stresses imposed by near and distant earthquakes. Following the Kaikōura mainshock, immediate and delayed triggering was observed across the North Island. However, incomplete earthquake catalogues in the lower North Island limited any meaningful interpretations on whether dynamic or static stress changes from Kaikōura induced an increase in seismicity rate in this region.

Using a novel workflow with integrated AI-based detection tools, we have extended a nationwide machine learning earthquake catalogue to detect and locate earthquakes in the Southern Hikurangi Margin between 2011 and 2018. Our catalogue contains 59,991 earthquakes, 23,460 of these being newly detected events, as well as high quality locations with reduced uncertainties and an improved magnitude of completeness. Using this enhanced catalogue, we conduct a statistical analysis of earthquake interactions in the Southern Hikurangi Margin following the Kaikōura mainshock and subsequent aftershock sequence. By integrating co-located matched-filter detections, we investigate the temporal variation in triggering following the mainshock and use this with Coulomb Stress modelling to investigate the processes driving a varied pattern of triggering. We categorise triggered seismicity into four groups based on the method of triggering and consider the role Slow Slip Events, ground water changes and crustal fault connectivity play in relation to these increased rates of seismicity in the lower North Island. We compare our results to other studies of dynamic and static triggering following the Kaikōura mainshock and put these into the context of other local and teleseismic triggering events.

Using AI-enhanced cataloguing approaches to illuminate faulting across the Cook Strait

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Cook Strait and the surrounding Wellington and Marlborough regions form a tectonically diverse and seismically 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 high-quality long-duration seismic data, there remains significant uncertainty in our understanding of the drivers of seismicity in the region, in particular, the role of crustal faults. Advancements in AI-based detection methods enable us to interpret seismicity at scales not previously possible. The integration of AI-enhanced methods allows us to develop and apply a novel automated workflow to generate a research-grade earthquake catalogue for the Southern Hikurangi Margin which can be used to better understand crustal faulting in the region. This workflow expands and improves our approach to national cataloguing, enabling further research into the Southern Hikurangi Margin's complex seismo-tectonic setting and a better understanding of present-day seismic hazard.

Our catalogue contains 59,991 earthquakes between 2011 and 2018, a increase of 1.4x over the GeoNet catalogue. Using both absolute locations and relative relocations to produce high quality, low uncertainty event origins, we first present the key structural features illuminated by this catalogue including subduction interface geometry, upper plate faulting and the presence of a double Wadati-Benioff Zone. We then use the fine-scale resolution of the catalogue to produce a more refined model of faulting in the Southern Hikurangi Margin than previously possible. We discuss the role of crustal faults in the Cook Strait in linking together the Marlborough Fault Zone with the North Island Dextral Fault Belt, before investigating how these faults intersect with the underlying subduction interface.

Transforming lakes into natural seismometers by combining fibre-optic seismology and slope stability modelling

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Sediments accumulating on lake beds provide detailed records of past large earthquakes. The strong shaking they cause leaves behind diagnostic stratigraphic fingerprints in lake basins. This includes turbidites, triggered by disturbances of lake-margin sedimentary landforms that evolve into sediment flows. Lake paleoseismology is now well established and being employed to increase knowledge of spatiotemporal earthquake behaviour in diverse tectonic settings globally. However, deriving quantitative information about strong ground motions and earthquake rupture parameters from these fingerprints remains challenging. To reveal the quantitative information provided by the records of earthquake-induced shaking preserved in the lake stratigraphy, we use a combination of fibre-optic seismology and slope stability analysis.

We apply this novel seismological method to Lake Tūtira in Aotearoa-New Zealand, of which the sedimentary infill revealed a ~7000 year record of seismic activity along the Hikurangi subduction zone, including several well-characterised historical events. For this purpose, we employ distributed acoustic sensing (DAS) to passively record ambient noise on kilometre-scale lengths of armoured fibre-optic cable deployed temporarily across different landforms of interest. These include fan deltas and sediment-draped slopes of Lake Tūtira that are known to fail at different shaking intensities, each leaving a distinct sedimentary signature on the bottom of the lake. The recorded waveforms are subsequently inverted to develop the depth-dependent measurements of shear-velocity required to parameterise physics-based dynamic slope stability models. The models will then be used to determine the shaking intensities required to cause each landform to fail. We present preliminary results on the combination of fibre-optic seismology and slope stability modelling and provide an outlook for the remainder of the project that aims to measure the susceptibility of lake marginal sedimentary landforms to earthquake-induced shaking, bringing us one step closer to transforming lakes into natural seismometers that have recorded earthquakes for thousands of years.

What I learnt from opening (and closing) a small, community-based, geology museum

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In April 2024, I set up a small geology and fossil centre in Waikuku, North Canterbury, New Zealand. After approximately three months of preparation, the centre opened to the public. What followed was a year-long experiment in sharing rocks, fossils and New Zealand's geological history with the local community. By January 2025, despite being open for only three mornings each week, the centre was attracting more than 1,000 visitors per month.

The museum provided visitors with access to fossils, rocks, minerals and other geological specimens from the local area. A central focus was on creating opportunities for hands-on exploration and encouraging visitors, particularly children, to engage directly with geological materials and to ask questions about the natural history of New Zealand.

Visitor interest and engagement, including which exhibits and activities proved most successful, and how different audiences interacted with the collection, has been tracked. Observations from the museum's operation provide insights into the value of tactile and interactive exhibits, the importance of large and visually striking specimens, and the role that small museums can play as accessible community assets.

The experience also highlighted significant practical challenges, including the financial and logistical realities of operating an independent museum. By sharing both successful approaches and aspects that did not work as intended, this presentation aims to provide a practical case study for scientists, educators and community organisations interested in developing public engagement initiatives around geology, palaeontology and natural history. The lessons learned suggest that even a small, independently operated museum can generate substantial community interest and provide meaningful opportunities for people to connect directly with New Zealand's geological and palaeontological heritage.

Two early Eocene billfishes from Hampden Beach, New Zealand

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Two large billfish crania from the Early Eocene of Hampden, New Zealand, provide important new insights into the early evolution of *Xiphioidei*. Phylogenetic analysis places both specimens among early-diverging billfishes and expands the known diversity and geographic distribution of the group during the Eocene.

The more complete specimen is referred to *Zealandorhynchus fordycei* gen. et sp. nov. and represents the most basal member of an extinct monophyletic lineage (Family Xiphiorhynchidae) that includes *Aglyptorhynchus* and *Xiphiorhynchus*. A second, partial cranium displays characters suggesting affinities with lineages related to Istiophoridae, Xiphiidae and the Eocene Blochiidae. However, the available material does not allow its precise phylogenetic position to be resolved, and it is therefore assigned to *Xiphioidei incertae sedis*.

The Hampden specimens represent significant additions to the sparse Early Eocene marine fish macrofossil record of New Zealand and demonstrate a greater diversity of billfishes in the South Pacific than previously recognised. Their occurrence within the former Weddellian Province indicates that billfishes had achieved a broad geographic distribution during the warm Eocene. Previously the known fossil record of early billfish was dominated by records from the Northern Hemisphere

Shallow seafloor seeps around Aotearoa New Zealand: distribution, morphology and controls

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Marine seafloor seeps host important ecosystems, often supporting complex benthic communities and influencing ocean productivity. In shallow coastal environments, seepage may also present an engineering hazard to offshore infrastructure. Although numerous seep sites are known around Aotearoa New Zealand, their nationwide distribution and morphology in shallow coastal waters remain poorly characterised.

Here, we compiled 41 publicly available hydrographic surveys from Toitū Te Whenua Land Information New Zealand to develop a systematic catalogue of shallow seafloor seep features. The compilation included 636 km² of bathymetric data, supplemented where available by water-column data and associated survey reports. Seep features were identified from bathymetry, water-column flares and annotated navigational charts reporting seep activity.

Seep features were identified across 31 distinct areas extending from Te Tai Tokerau to Fiordland. Evidence of active seepage in the form of water-column flares was observed in three regions, although suitable water-column data were not available for all surveys. Seep features occurred at an average water depth of ~24 m, with a maximum depth of 57 m. Most pockmarks had <1 m of relief, although relief reached up to 10 m. Their morphology and spatial organisation varied considerably, from isolated and linear arrangements to dense clusters and widespread diffuse fields. This variability may reflect differences in geological setting, sediment properties and fluid sources, including gas and groundwater.

This compilation provides the first nationwide synthesis of shallow seep features from available hydrographic surveys in the near-coastal zone around Aotearoa New Zealand. It establishes a baseline for investigating their distribution, origins, ecological significance, and potential implications for offshore infrastructure.

3D seismic mapping of the stratigraphy and structure of North Taranaki Bight, New Zealand

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Deep-water depositional elements, such as submarine channels, slope fans, and mass-transport deposits, record sediment routing, gravity-flow processes, and slope instability in marine basins. The Neogene succession of the Northern Taranaki Basin provides a useful setting to examine how these elements were organised during basin-margin progradation and structural development. This study applies seismic geomorphological analysis to the Kahu 3D seismic volume, focusing on the Late Miocene to Early Pliocene interval.

Stratigraphically constrained seismic slices were used to visualise depositional patterns in plan view and examine how they changed through time. Depositional elements were interpreted based on their morphology, geometry, and spatial relationships, with selected seismic attributes used to enhance their expression and constrain their distribution across the basin margin.

Preliminary observations show that submarine channels, over bank deposits, slope fans, and mass-transport deposits occur in close spatial association. Channelised systems are commonly accompanied by overbank deposits, while slope fans occur farther downslope, indicating the progressive routing and redistribution of sediment across the basin margin. Mass-transport deposits are locally present and record episodes of slope instability that disrupted this depositional system. Together, these relationships suggest that sediment gravity flows, slope instability, and evolving structural relief controlled the distribution and organisation of deep-water depositional elements.

The study provides a detailed view of deep-water architecture at the scale of individual depositional elements, extending beyond conventional stratigraphic descriptions at the formation scale. By examining the spatial relationships between channels, over bank deposits, slope fans, and mass-transport deposits, the results provide new insight into how sediment was routed and deposited along a structurally influenced basin margin.

Precursor of a powerful large glacier landslide causing tsunami floods in the 26 August 2026 Nepal disaster

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On 26 August 2026, a catastrophic ice-rock landslide occurred near the border region between China and Nepal, triggering devastating tsunami-like flash floods. This article reports the preliminary precursor detection of this powerful glacier landslide using an enhanced optical Pixel Offset Tracking (enhanced POT) method. By analysing hundreds of free satellite scenes from 2017 to 2026, we identified over 100 metres of pre-failure deformation and a clear bifurcation phase starting in January 2026, which was closely synchronized with anomalous warming trends. We present a new cascading hazard mechanism: landslide-induced tsunami floods in deglaciating mountains, driven by the directional consistency between the landslide movement and the river flow, solving the missing water puzzle of this event and past events. These findings underscore the potential of enhanced POT for regional early warning and the complexity of climate-driven cryospheric hazards.

Helium enrichment Patterns in coal measures of the Qinshui Basin, China

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Coal measures are widely distributed across China and, besides containing abundant coalbed methane and shale gas, can also host the critical and scarce gas helium. Helium is widely used in aerospace, nuclear technology, medical imaging, and semiconductor manufacturing, underscoring the need for improved resource assessment and exploration. However, the conditions controlling helium accumulation and distribution in coal measures remain poorly understood.

The Qinshui Basin hosts China's largest high-rank coalbed methane production base, with recent reports of helium-bearing and helium-enriched gas within Carboniferous–Permian coal measures. This study investigates the geological controls on helium generation, migration, accumulation, and preservation, with particular focus on source contributions, fault-controlled migration, and changes under varying temperature–pressure conditions. Gas composition and isotopic tracer analysis, resource estimation, geological analogues, and probabilistic methods are used to evaluate the controls on helium enrichment and spatial distribution.

Noble gas isotopic tracing indicates that helium is predominantly of crustal radiogenic origin ($^3He/^4He$ =0.0045–0.0124 Ra). Methane desorbed from coal seams can dilute helium in groundwater, making low-gas-yield reservoirs more favourable for helium enrichment. Deep faults provide important migration pathways, while preservation is strongly influenced by lithology and water saturation. Helium diffuses more rapidly through coal than mudstone, while high water saturation reduces diffusion. Late-stage tectonic uplift is estimated to have caused ~90% helium loss, explaining the generally low helium concentrations observed today.

Despite low helium grades, the Qinshui Basin may contain considerable total helium resources. Assessment should therefore focus on helium source conditions, fault configuration, and preservation effectiveness, providing a framework for evaluating similar coal-measure systems elsewhere.

Distal downflow limbs as complementary storage targets for dissolved CO_2 in TVZ-style geothermal systems

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High-enthalpy geothermal fields in the Taupō Volcanic Zone (TVZ) are increasingly reinjecting dissolved non-condensable gases (NCGs) to reduce emissions. However, most CO_2 storage assessments focus on the active production reservoir rather than the wider convective footprint of the field. This study evaluates whether the distal downflow limbs of a TVZ-style convective cell can provide a complementary storage domain for dissolved CO_2 while remaining hydraulically separated from the active reservoir and production area. A three-dimensional model of a generic geothermal field simulates natural convection, production, near-field reinjection and partial diversion of dissolved CO_2 to a downflow target 6 km away, tracking dissolved CO_2 plume migration, storage retention, phase stability and overpressure propagation over 2,100 years.

Diverting 10% of reinjected water into the downflow limb allows approximately 5.0 Mt of CO_2 to be injected in dissolved phase, with most of the injected mass retained within the system after 1,000 years and negligible free-gas formation under modelled conditions. Positioning near-field reinjection between the downflow injection point and production creates a hydraulic buffer that keeps the overpressure front shallower than about 5 km and delays plume return to the upflow zone by approximately 90 years compared with an opposing layout. A conservative sensitivity analysis using reduced basement porosity and a connected fracture pathway shows plume return can accelerate by up to an order of magnitude, yet retention exceeds 98 % at 1,000 years and 81 % at 2,100 years in every case tested.

These results suggest the potential for distal downflow injection to expand dissolved CO_2 storage capacity while complementing conventional geothermal reinjection. Successful implementation will depend on reinjection-well placement and detailed characterisation of regional permeability, basement structures, and hydraulic connections to production zones.

Bridging the gap: how can ESSENZ and GSNZ cultivate the next generation of Aotearoa geoscientists

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The future of geosciences in Aotearoa New Zealand relies heavily on inspiring and recruiting young minds at the secondary school level. Earth and Space Science Educators New Zealand (ESSENZ) represent over 350 teachers of Earth & Space Science in New Zealand schools. We serve as a critical gateway, connecting Year 7 to 13 students with the profound mechanisms shaping our planet. However, a persistent disconnect remains between high school science classrooms and university or industry-level geoscience pathways. This presentation explores the vital role of ESSENZ in fostering early student interest in Earth systems and outlines a strategic framework for closer collaboration with the Geoscience Society of New Zealand (GSNZ). By aligning outreach efforts, both organizations can achieve mutual benefits. GSNZ gains a visible, sustained pipeline of passionate future members and students and a vehicle for sharing research findings, while ESSENZ educators gain access to educational enrichment and professional support. Ultimately, this collaborative approach strengthens the entire geoscience ecosystem, ensuring secondary school enthusiasm translates into lifelong scientific careers.

Ocean-rafted pumice in New Zealand as a proxy for reconstructing eruption records in the Southwest Pacific – a pilot study

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Reconstructing the frequency and magnitude of past eruptions is fundamental to volcanic hazard assessment, yet eruption histories remain poorly constrained for many submarine and island volcanoes because their deposits are largely inaccessible on the seafloor. This challenge is especially relevant in the Tonga-Kermadec Arc, where numerous submarine volcanic centres are capable of generating large explosive eruptions. Ocean-rafted pumice offers a promising proxy for offshore volcanism, providing a widespread and accessible archive of eruptive activity. Produced during explosive eruptions, pumice rafts can disperse thousands of kilometres before becoming stranded and preserved in coastal environments, recording eruptions that may otherwise leave little accessible geological evidence.

Despite widespread pumice strandings around New Zealand, including material sourced from volcanic centres throughout the southwest Pacific and as far afield as the South Atlantic, their potential as a long-term archive of submarine volcanism remains largely unexplored. This pilot study investigates the occurrence, provenance, and depositional setting of ocean-rafted pumice along New Zealand coastlines as a first step towards evaluating its utility for eruption history reconstructions.

Pumice samples collected from selected North Island and Chatham Island beaches were analysed using electron microprobe glass geochemistry to establish their compositional fingerprints. Preliminary results identify pumice sourced from the Taupō Volcanic Zone, older New Zealand volcanic centres, and the Tonga-Kermadec Arc. Marked regional variability in pumice abundance and composition reflects differences in eruptive source, marine transport pathways, and local depositional environments. Pumice occurs from the modern high-tide zone into adjacent dune systems, highlighting both contemporary dispersal processes and the potential for long-term preservation within Holocene coastal sequences.

These findings demonstrate the value of stranded pumice as a proxy for reconstructing eruption histories that are otherwise poorly preserved in the geological record and provide a foundation for developing Holocene records of explosive volcanism from submarine volcanic systems across the southwest Pacific.