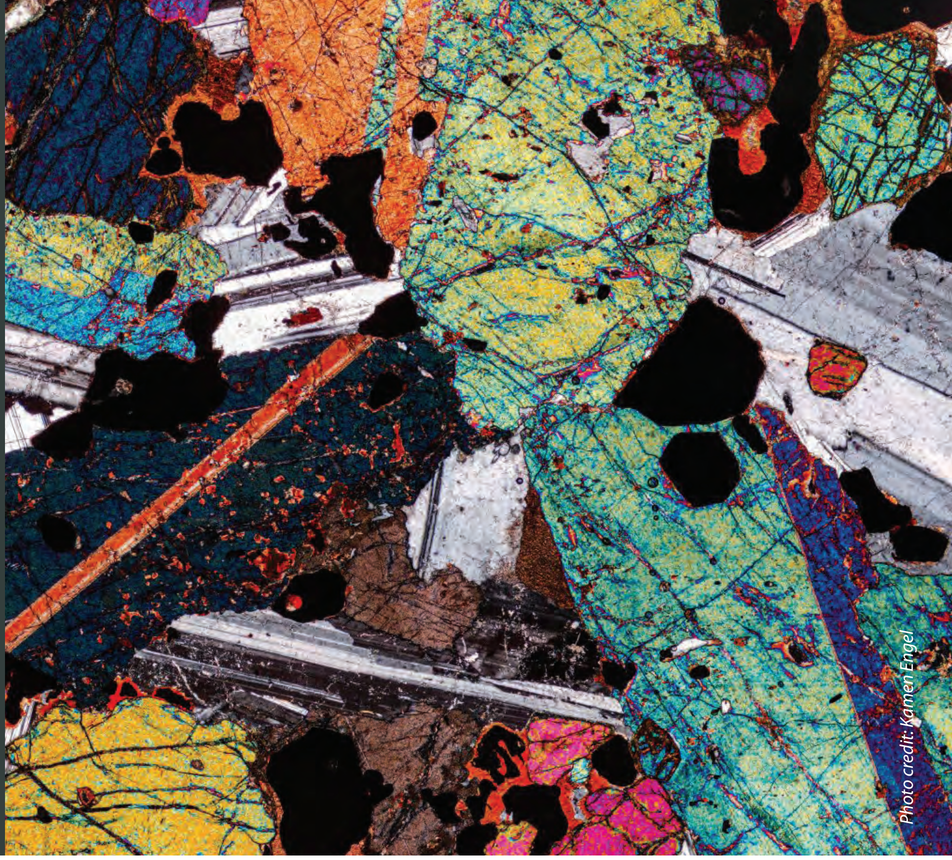
Geoscience Society of New Zealand

Annual Conference 2020

22–25 November

University of Canterbury
Christchurch



ABSTRACT VOLUME

CONFER.NZ/GSNZ2020

Bibliographic Reference for Abstracts

Author A., Author B., 2020. Title. In: Bassett K. N., Nichols A. R. L., Fenton C. H. eds. Geosciences 2020: Abstract Volume. Geoscience Society of New Zealand Miscellaneous Publication 157A. Geoscience Society of New Zealand, Wellington, pp. 123.

Geoscience Society of New Zealand Miscellaneous Publication 157A
ISBN (online): 978-0-473-55115-5
ISSN (online): 2230-4495

CONTENTS

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We would like to extend a very big thank you to all those that helped organise and run the sessions, for their time, effort and contributions to this year's conference.

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Sally Watson (NIWA)
Tom Wilson (University of Canterbury)
Holly Winton (Victoria University of Wellington)
Hisham Zarour (Stantec)

FIELD TRIP LEADERS

We would like to extend a very big thank you to the field trip leads for their time, effort and contributions to this year's conference.

Brandy Alger (University of Canterbury, QuakeCore)
Peter Almond (Lincoln University)
Mac Beggs (University of Canterbury)
Alan Bischoff (University of Canterbury)
Clark Fenton (University of Canterbury)
Darren Gravley (University of Canterbury/Frontiers Abroad)
Sam Hampton (University of Canterbury/Frontiers Abroad)
Matthew Hughes (University of Canterbury)
Nick Jackson (Elemental Petroleum Consultants)
Bill Leask (Elemental Petroleum Consultants)
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Their support has contributed towards our being able to provide a comprehensive programme of quality content and excellent value for all participants.

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ERUPTION BREWING LYTTELTON

Sunday 22 November 2020

	Field trip
	Kaikoura earthquake surface ruptures, landslides and building damage Leader: Andy Nicol (University of Canterbury)

Monday 23 November 2020

*STUDENT PRESENTATIONS

09.00	**Registration** Venue: C-Block Foyer		
10.00 - 10.30	**Conference Opening** **Venue: C1** Mihi Whakatau Conference Opening Address – Cheryl de la Rey, Vice-Chancellor, University of Canterbury Conference Opening Welcome – Kari Bassett, Conference Convenor		
10.30 - 11.00	**Plenary 1** **Venue: C1** Braiding geoscience and mātauranga Māori: the case for a trans-epistemological approach **Clare Wilkinson, School of Earth and Environment, University of Canterbury**		
11.00 - 12.00	**1A: Unravelling the Seascape** **Unravelling the seascape: processes that shape the marine environment of Aotearoa/ New Zealand**	**1B: Hazards Symposium** **Creating partnerships between policy, practice & research** **Policies and strategies for risk reduction** *In association with Silver Sponsor EQC*	**1C: Cryosphere** **The cryosphere- Southern Alps and ice deformation to Antarctica**
	Chair: Sarah Seabrook & Jess Hillman	**Chair: Andy Nicol**	**Chair: Heather Purdie & Lauren Vargo**
	Venue: C1	**Venue: C2**	**Venue: C3**
11.00 - 11.15	An Unusual Fossil Duck from the Greta Formation of North Canterbury gives an insight into the Fauna of late Miocene Coastal New Zealand. **R. Paul Scofield**	How does central government use and promote science in disaster risk reduction? **Sara-Jayne McCurrach**	*The role of atmospheric rivers in snow hydrology of the Southern Alps **Rasool Porhemmat**
11.15 - 11.30	The last Gargantuan Penguin – an Eocene relict in the late Oligocene of the South Island, New Zealand? **Marcus Richards**		*Temperature and strain controls on ice deformation mechanisms: insights from the microstructures of samples deformed to progressively higher strains at -10, -20 and -30 °C **Sheng Fan**
11.30 - 11.45	*New Puzzle Whale Pieces Together Past Phylogeny **Dannielle Eagles**	Science into policy: The role of relationships in effective natural hazard science communication **Bill Fry**	The Priestley Glacier Deformation Experiment **David Prior**
11.45 - 12.00	New Zealand and IODP/ICDP: past, present, and future **Stuart Henrys**		Early and middle Miocene ice sheet dynamics in the Ross Sea: Results from core-log-seismic correlation **Lara F. Pérez**
12.00 - 13.30	**12.00 - 13.30** **Lunch, meetings & poster viewing** Venue: Sponsor & Exhibiton Area, C-Block		

12.30 - 13.30	**12.30 - 13.30** **All lunch time meetings are located in the Ernest Rutherford Building**				
	Venue: ER219	**Venue: ER220**	**Venue: ER221**	**Venue: Meet in the foyer of C-block**	**Venue: Puaka-James Hight - Library**
	Student Workshop: **The Road to Publication: Advice from Journal Editors** Presented by Kari Bassett and Fei He	**GeoNET Strategic Review** Catherine Ross	**Geochemistry SIG meeting** Sebastian Naeher	**Tour of the Ernest Rutherford Building** Rob Spiers	**Viewing of signed copy of William Smith's geological map of England and Wales (1815)**

Monday 23 November 2020 cont.

13.30 - 15.30	**2A: Unravelling the Seascape** **Unravelling the seascape: processes that shape the marine environment of Aotearoa/ New Zealand**	**2B: Hazards Symposium** **Creating partnerships between policy, practice & research. What does local government need from scientists?** *In association with Silver Sponsor EQC*	**2C: Cryosphere** **The cryosphere - Antarctica: past, present and future**
	Chair: Jess Hillman & Sally Watson	**Chair: James Thompson**	**Chair: Alex Gossart & Lauren Vargo**
	Venue: C1	**Venue: C2**	**Venue: C3**
13.30 - 13.45	The Seabed 2030 Project: Collating bathymetry data in the South&West Pacific Ocean **Arne Pallentin**	Barriers and solutions for risk reduction: what does local government want/need from scientists? **Simon Markham**	Tracing Antarctic Cryosphere Origins to Climate And Tectonics: A new IODP Proposal **Robert Mckay**
13.45 - 14.00	Low-Energy, Erosional Boulder Beaches, Eastern Tasman Bay, New Zealand **Warren Dickinson**		*Meteoric ground ice in mid-Miocene permafrost: a paleo-temperature proxy, upper McMurdo Dry Valleys of Antarctica **Marjolaine Verret**
14.00 - 14.15	Dynamic seafloor processes within the Subtropical Frontal Zone on the Chatham Rise and implications for regional sediment and organic carbon budgets **Scott Nodder**	Key issues for practitioners dealing with multiple natural hazards **Marion Schoenfeld**	*Sub-ice shelf sedimentary record at Kamb Ice Stream Grounding Zone, Siple Coast, West Antarctica **Theo Calkin**
14.15 - 14.30	HADAL sediment cores recovered from >9000 m water depth contain evidence of life and turbidites in the Kermadec Trench **Alan Orpin**		The SWAIS 2C Project - Sensitivity of the West Antarctic Ice Sheet in a Warmer World **Richard Levy**
14.30 - 14.45	**Keynote Speaker** Temporal changes in bedform morphology in shallow marine environments **Marta Ribó**	Earthquake risk treatment – understanding trade-offs and building buy-in **Hugh Cowan**	*Integrating proxy and model estimates of Antarctic climate variability over the last millennium **Olivia Truax**
14.45 - 15.00	High sedimentation rates, earthquakes and the Tuaheni Landslide Complex offshore Tūranganui-a-Kiwa **Joshu Mountjoy**		*Stabilizing and readvancing the grounding line of Pine Island Glacier **Alanna Alevropoulos-Borrill**
15.00 - 15.15	Spatio-temporal flow processes of a co-seismic turbidite: the Kaikōura Turbidite **Lorna Strachan**	Facilitated Q/A and panel discussion	*Investigating the seasonal dynamics of the Ross Ice Shelf, Antarctica using remote sensing data **Francesca Baldacchino**
15.15 - 15.30	What we do in the shallows: Natural and anthropogenic seafloor geomorphologies in a drowned river valley, New Zealand **Sally Watson**		Airborne sea ice thickness measurements in the western Ross Sea **Wolfgang Rack**
15.30 - 16.00	**15.30 - 16.00** **Afternoon tea** Venue: Sponsor & Exhibition Area, C-Block		

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Monday 23 November 2020 cont.

16.00 - 17.30	**3A: Unravelling the Seascape** **Unravelling the seascape: processes that shape the marine environment of Aotearoa/ New Zealand**	**3B: Hazards Symposium** **Creating partnerships between policy, practice & research. Promoting practitioner, iwi and researcher dialogue** *In association with Silver Sponsor EQC*	**3C: Petroleum** **Geoscience of Petroleum in New Zealand (in association with Oil and Gas SIG)**
	Chair: Sally Watson & Sarah Seabrook	**Chair: Richard Smith**	**Chair: Mac Beggs & Joanna Elliot**
	Venue: C1	**Venue: C2**	**Venue: C3**
16.00 - 16.15	*Acoustic and geomorphic predictors of hydrothermal vents in an active back arc, offshore Taupō Volcanic Zone, New Zealand **Erica Spain**	Researcher-Practitioner integrated natural hazards research programmes – successes, lessons and opportunities **Tom Wilson & Sarah Beaven**	After the Cretaceous Cenozoic Research Project: 25 years of research and discovery in New Zealand's sedimentary basins **Kyle Bland**
16.15 - 16.30	How do subsurface processes of faulting and fluid flow impact the seascape? **Jess Hillman**	Lessons from early career Māori researchers working with Māori communities on community-based risk and resilience research **Kristie-Lee Thomas & Lucy Kaiser**	A window on Zealandia: how can we unlock the scientific value of decades worth of offshore petroleum exploration? **Jess Robertson**
16.30 - 16.45	Ecosystem Vulnerability to Hydrate Mining: Tracking the sphere of influence of methane seeps **Sarah Seabrook**		Reservoir and seal properties of volcaniclastic deposits from the Kora Volcano, offshore Taranaki Basin, New Zealand **Jessica Fensom**
16.45 - 17.00	**Keynote Speaker** *Concentrated gas hydrate deposits in thrust-related anticlines: insights into their evolution and assessment of hydrate volumes from the southern Hikurangi Margin **Francesco Turco**	Risk reduction through land-use planning for natural hazards **Wendy Saunders**	How McKee Oil Field changed the petroleum scene in New Zealand **Julie Palmer**
17.00 - 17.15	Seafloor pockmarks of the Chatham Rise, Canterbury Slope and Bounty Trough - distribution, structure and potential formation mechanisms **Bryan Davy**	Facilitated Q/A and panel discussion	Explorations in the nether: a history of coal seam gas in New Zealand **Tim Moore** (Virtual)
17.15 - 17.30	Seafloor pockmarks on the Chatham Rise and Bounty Trough – an overview on R/V Tangaroa Voyage 2006 **Ingo Pecher**		Māui field history **Christine Coppell** (Virtual)
17.30 - 19.00	**17.30 - 19.00** **Poster Session 1** **Venue: Mezzanine Floor, C-Block** *Brought to you by Silver Sponsor NIWA*	**17.30 - 18.30** **Icebreaker Reception** **Venue: Sponsor & Exhibition Area, C-Block** Join in for a relaxed social evening. Food and drink will be available. Enjoy local craft beer provided by *Eruption Brewing*.	
19.00 - 20.30	**Public Lecture** **Venue: C1** **On shaky ground – the contribution of geoscience to disaster risk management in Aotearoa-New Zealand: Lessons from recent Earthquakes.** **Speakers**: Andy Nicol, Professor of Earthquake Geology, University of Canterbury; Jo Horrocks, Chief Resilience and Research Officer, Earthquake Commission; Marion Schoenfeld, Senior Hazards Analyst, Christchurch City Council **Facilitated by** Tom Wilson - Professor of Disaster Risk and Resilience, University of Canterbury		
19.30	**19.30 Onwards** **Early Career Researchers Mixer - Jenni Hopkins** **Location: Volstead, 55 Riccarton Road**		

Tuesday 24 November 2020

07.00	**Registration** Venue: C-Block Foyer		
08.00 - 08.30	**Plenary 2** **Venue: C1** Ability not gender: New Zealand women geologists in Antarctica. **Margaret Bradshaw, School of Earth and Environment, University of Canterbury**		
08.30 - 10.30	**4A: Volcanism** **Overview and modelling studies**	**4B: Hazards** **Past, present, and future of natural hazard geoscience**	**4C: Sediments** **Sedimentation from Source to Sink: Modern Analogues and Ancient Examples** **(in association with Sedimentology SIG)**
	Chair: Jenni Hopkins & Karoly Nemeth	**Chair: Matiu Prebble**	**Chair: Andrew La Croix**
	Venue: C1	**Venue: C2**	**Venue: C3**
08.30 - 08.45	**Keynote Speaker** Volcanism between New Zealand and New Caledonia: a stretched Late Eocene to Early Miocene magmatic arc on the Loyalty and Three Kings Ridges **Nick Mortimer**	Urbanisation and lava flow advancement: How the presence of buildings influences lava flow areal footprint modelling **Sophia Tsang**	The present is the key to the past: an online resource for modern depostional systems **Angela Griffin**
08.45 - 09.00	Volcanoes Buried in Te Riu-a-Māui/Zealandia Sedimentary Basins **Alan Bischoff**	Te tai pari o Aotearoa - new estimates of future sea level along New Zealand's coastline **Richard Levy**	*Susceptibility Factors Controlling the Occurrence of Slow-Moving Large Landslides in the Whanganui Basin Sediments, North Island **Forest Williams**
09.00 - 09.15	Recognition of cryptic igneous intrusions in New Zealand sedimentary basins **Jane Newman**	Answering to stakeholders: Sensitivity of liquefaction hazard during earthquakes to sea-level rise in the San Francisco Bay Area, California **Anne Wein** (Virtual)	*Process sedimentology of the Waikato River mouth, Port Waikato, New Zealand **Anya Podrumac**
09.15 - 09.30	New Zealand's mantle peridotite and serpentinite **James Scott**	Historical seismograms - Preserving and utilising a unique 100-year continuous record of New Zealand earth observations **Paul Viskovic**	*Insights from benthic foraminifera on Lyttelton Harbour/Whakaraupo sedimentation and anthropogenic impacts **Zoë Dietrich**
09.30 - 09.45	*Gas-particle transport and sedimentation of pyroclastic currents across topographic obstacles **Lucas Corna**	After the Big One: The Potential Impact of an Aftershock Sequence Following a Major Earthquake on the Hikurangi Subduction Interface **David Burbidge**	Evaluating post-depositional disturbance of distal tephra records from the 12.9 ka BP eruption of Laacher See Volcano through multidisciplinary investigations at Paddenluch and Krumpa, Germany **Anke Zernack**
09.45 - 10.00	*Hiding Behind an Obstacle? Probing the Hazard Impacts Inside Pyroclastic Currents Across Topographic Barriers **Daniel Uhle**	NZ DART array and tsunami early warning **Bill Fry**	*Measuring landscape evolution from inception to senescence; an example from the Cooloola Sand Mass, Australia **Nicholas Patton**
10.00 - 10.15	Constructing a model volcanic fissure for erupting a ton of wax **Rosie Cole**	An eruption in search of a volcano? The evidence at source for the mid-15th century Kuwae event **Chris Ballard** (Virtual)	Murchison Basin sandstone provenance: early Miocene Pacific Plate uplift and erosion **Matt Sagar**
10.15 - 10.30	*Shaky volcanology: how do bubbles respond to seismic waves in the laboratory? **Gilles Seropian**	Past natural hazards, environmental change, and oral traditions in Polynesia: case studies from Tikopia and Rapa Nui (Easter Island) **Matiu Prebble**	*Stratigraphy and Preliminary Results from the May 2019 drilling campaign of the 3.48 Ga Dresser Formation, Pilbara, Western Australia. **Michaela Dobson**
10.30 - 11.00	**10.30 - 11.00** **Morning tea** Venue: Sponsor & Exhibition Area, C-Block		

Tuesday 24 November 2020 cont.

11.00 - 13.00	5A: Volcanism Caldera Volcanism	5B: Engineering Geology Recent Advances in Engineering Geology	5C: Climate Climate Past and Present (in association with Friends of the Pleistocene SIG)
	Chair: Alan Bischoff & Karoly Nemeth	**Chair: Richmond Beetham & Clark Fenton**	**Chair: Katelyn Johnson & Shaun Eaves**
	Venue: C1	**Venue: C2**	**Venue: C3**
11.00 - 11.15	Taupō: what we know (and don't know) about New Zealand's youngest supervolcano **Simon Barker**	**Keynote Speaker** Building on Difficult Ground - Two Case Studies **David Bell**	**Keynote Speaker** Urban greenhouse gas emission response to COVID-19 shutdowns in New Zealand and North America **Jocelyn Turnbull**
11.15 - 11.30	*Componentry and textural characteristics of pyroclasts from the Taupo 232 CE Y2 eruption – implications for conduit dynamics and eruption evolution. **Hannah Walters**	New Zealand Community Fault Model **Hannu Seebeck**	Quaternary evolution of one of the world's largest coastal dune systems, Fraser Island and Cooloola, SE Queensland, Australia **Jamie Shulmeister**
11.30 - 11.45	*The Conditions and Dynamics of Magma Fragmentation and Plume Stability during the Y5 Phase of the Taupo 232 CE Eruption **Sarah Tapscott**	It's not Over When the Shaking Stops: Lessons in Resilience from the Kaikoura Earthquake **Richard Justice**	A data-model comparison of marine primary productivity during the Last Glacial Maximum and the Last Inter-Glacial **Elizabeth Keller**
11.45 - 12.00	*Rhyolite magma factory in the central Taupō Volcanic Zone: magma extraction depths for dome eruptions complementing structural models of the crust **Sarah Smithies**	Documenting some of what we learned from mitigating rockfall risk following the 2016 Kaikoura earthquake **Rori Green**	*New fossil wood from Zealandia and its use in reconstructing paleoclimate **Mathew Vanner**
12.00 - 12.15	Violent Taupō eruption triggered a megathrust earthquake in 6th century CE **Brendan Duffy** (Virtual)	*Laboratory simulations of rainfall-induced landslide reactivation mechanisms following the 2016 Kaikoura Earthquake **Joshua Lee**	Climate signals from Foulden Maar: Temperature, rainfall, elevated atmospheric CO2 and global greening in earliest Miocene Zealandia **Daphne Lee**
12.15 - 12.30	An idea: scientific drilling project “interaction”: interaction between life, rifting and caldera tectonics in Okataina **Pilar Villamor**	Reinforced Soil Bund as passive protection structures: the New Zealand Experience **Eric Ewe**	*Constraining the age and depositional processes of Taylor 2 Drift with cosmogenic nuclides in Pearse Valley, Antarctica **Jacob Anderson**
12.30 - 12.45	Mafic magmatism in the Taupo Volcanic Zone, New Zealand: insights into the birth and death of very large volume rhyolitic systems **Georg Zellmer**	*Spatial and temporal aspects of Deep-Seated Gravitational Slope Deformations on the South Island of New Zealand **Romy Ridl**	Filling the gaps in Antarctica’s observational records using Gaussian Process Regression **Mario Krapp**
12.45 - 13.00	**Keynote Speaker** *The 2.1 Ma Waiteariki Ignimbrite: defining a new super-eruption at the onset of TVZ volcanism **Marlena Prentice**	*Geomorphology and geotechnical characterization of the Queenstown Hill landslide **Laura Gnesko**	Emergence of critical climate states during the Plio-Pleistocene **Nicholas Golledge**
13.00 - 14.30	**13.00 - 14.30** **Lunch, meetings & poster viewing** Venue: Sponsor & Exhibition Area and Poster Display, C-Block		

13.30 - 14.30	**13.30 - 14.30 All lunch time meetings are located in the Ernest Rutherford Building**				
	Venue: ER213	**Venue: ER219**	**Venue: ER 221**	**Venue: Meet in the C-block foyer**	**Venue: Puaka-James Hight - Library**
	LAVANZ SIG / IAVCEI VolcanoFest meeting Geoff Kilgour/Ben Kennedy	**Life after University: Industry Advice for Students** Clark Fenton	**Friends of Pleistocene SIG meeting** Peter Almond	**Tour of the Ernest Rutherford Building** Rob Spiers	**Viewing of signed copy of William Smith's geological map of England and Wales (1815)**

Tuesday 24 November 2020 cont.

14.30 - 16.30	**6A: Volcanism** **Intermediate Volcanism**	**6B: Transition Zone** **Subduction to Strike-Slip Transition in Central New Zealand**	**6C: Climate** **Climate Past and Present (in association with Friends of the Pleistocene SIG)**
	Chair: Alan Bischoff & Jenni Hopkins	**Chair: Emily Warren-Smith & Ilma del Carmen Juarez Garfias**	**Chair: Andrew Lorrey & Peter Almond**
	Venue: C1	**Venue: C2**	**Venue: C3**
14.30 - 14.45	**Keynote Speaker** Whakaari/White Island: a review of New Zealand's most active volcano **Geoff Kilgour**	Seismogenesis Hikurangi Integrated Research Experiment (SHIRE): a lot has been happening in Middle Earth **Stuart Henrys**	**Keynote Speaker** Bye Bye, Bipolar Seesaw? **David Barrell**
14.45 - 15.00	Real-time Eruption Forecasting and Early Warning at Whakaari **Shane Cronin**	*What controls the along-strike segmentations of shallow slow slip events? Insights from 3D numerical modeling of slow slip events along the Hikurangi margin, New Zealand **Andrea Perez**	What lies beneath? A palynological and sedimentological history of the Wellington Basin (CBD) over the Late Pleistocene **Matthew Ryan**
15.00 - 15.15	*Hydrothermal rock alteration as a possible control on eruption dynamics at Whakaari volcano **Shreya Kanakiya**	*Adjoint tomography of the Hikurangi subduction zone and New Zealand's North Island using an automated workflow **Bryant Chow**	Latitudinal migration of Southern Hemisphere westerly winds during the early Holocene **Greer Gilmer**
15.15 - 15.30	Phreatic eruptions from hyper-acidic wet volcanic systems: The role of hydrothermal sealing in the 27 April 2016 eruption from White Island, New Zealand **Bruce Christenson**	Assessment of tsunami source complexities at the Northern Tonga Trench and comparisons with local tsunami source potential at the Southern Hikurangi margin **Shaun Williams**	Multiproxy speleothem records from Aotearoa New Zealand map latitudinal shift of westerly winds across the Early Holocene **Christopher Wood**
15.30 - 15.45	Reconstructing the dynamics of jets and pyroclastic currents of the 9 December 2019 Whakaari eruption **Ermanno Brosch**	**Keynote Speaker** 10-years of earthquakes on and around the 2016 M7.8 Kaikōura earthquake **Calum Chamberlain**	Climate modulation of laminae deposition in Adélie Land, East Antarctica **Katelyn M. Johnson**
15.45 - 16.00	Ambient Noise Velocity Changes at Whakaari, White Island 2012-2020 **Katie Jacobs**	Heterogeneous stresses and brittle-ductile deformation during shallow crustal faulting, Hungaroa Fault Zone, Hikurangi Subduction Margin, New Zealand **Marcel Mizera**	*Significant variations in late Holocene South Pacific gyre strength **Nicholas Hitt**
16.00 - 16.15	The December 9 eruption of Whakaari/White Island **Geoff Kilgour**	Material properties, from seismic attenuation, influence multiple fault rupture and ductile creep of the Kaikoura Mw 7.8 earthquake, New Zealand **Donna Eberhart-phillips**	A 7300 year record of long- and short-term environmental changes (inc. a tsunami) in a backbarrier wetland, Moawhitu, Rangitoto ki te Tonga/d'Urville Island **Catherine Chagué**
16.15 - 16.30	**Keynote Speaker** The geological history and hazards of a long-lived stratovolcano, Mt. Taranaki, New Zealand **Shane Cronin**	Marlborough Fault System: topographic fabric of a complex 4D transition zone in central New Zealand **Phaedra Upton**	Decadal scale changes in flood frequency over the past 2600 years from an annually resolved sediment record from Lake Ohau **Gavin Dunbar**
16.30 - 17.30	**16.30 - 17.30** **Afternoon Tea and Poster Session 2** Venue: Sponsor & Exhibition Area and Mezzanine Level, C-Block Local craft beer provided by *Eruption Brewing* *Poster Session brought to you by Silver Sponsor NIWA*		
17.30 - 18.30	**GSNZ AGM** **Venue: C1**		
18.45 / 19.00	**18.45 / 19.00 – Late** **Conference Dinner** Venue: Ti-Kouka, Haere-roa, UCSA Events Centre, University of Canterbury **Theme: mā pango, mā whero : collaboration and cooperation to achieve a goal: red and black**		

Wednesday 25 November 2020

07.00	**Registration** Venue: C-Block Foyer		
08.00 - 08.30	**Plenary 3** **Venue: C1** Prediction of seismic hazards in NZ using physics-based methods: Opportunities for integration across the geosciences **Brendon A. Bradley, Professor of Earthquake Engineering, University of Canterbury and Director, QuakeCoRE: The NZ Centre for Earthquake Resilience**		
08.30 - 10.30	**7A: Volcanism** **Trip around the South Pacific**	**7B: Active Tectonics** **Active tectonics of New Zealand - 40 years of advances**	**7C: Minerals** **Mineral Deposits: Geology, Exploration and Resources** **(in association with AusIMM)**
	Chair: Jenni Hopkins & Alan Bischoff	**Chair: Rob Langridge**	**Chair: Michael Gazley**
	Venue: C1	**Venue: C2**	**Venue: C3**
08.30 - 08.45	A granite in the Otago Schist: Caravel-1, offshore north Otago **Andy Tulloch**	**Keynote Speaker** Reflections on advances in active tectonics in New Zealand in the past 40 years **Kelvin Berryman**	Geochemical signatures of epithermal Au-Ag deposits of the Hauraki Goldfield, Coromandel Volcanic Zone, New Zealand **Anthony (Tony) Christie**
08.45 - 09.00	*Geochemistry of the 26th June 2019 eruption products from Ulawun volcano, Papua New Guinea **Marco Rebecchi**	AF8: Five years of science and emergency management collaboration to improve resilience in the South Island **Caroline Orchiston**	*Delineating Mineral Resources By Integrating Biogeochemical And Geological Exploration Approaches Using Hyperspectral Remote Sensing **Rupsa Chakraborty**
09.00 - 09.15	*Facies architecture of the NE sector of Lyttelton Volcano, Banks Peninsula **Marcos Rossetti**	Clyde Dam, Otago: 40 years of hazards science **Mark Stirling**	Nimbyism in Marlborough - Reconsenting Barracks Quarry **David Bell**
09.15 - 09.30	Understanding composite volcano architecture through hydrothermal alteration mapping – A case study for Mt Ruapehu, New Zealand **Gabor Kereszturi**	*Ground Motion Simulations for Dunedin - Mosgiel Area **Anna Kowal**	*Expanding the Footprint of Orogenic Gold: Trace Elements in Sulphides Showing Potential **Harry Davies**
09.30 - 09.45	*Magma-ficent Earthquakes: Using historical records to inform baseline seismicity in the Auckland Volcanic Field **Sian Camp**	Filling the gaps: progress toward an improved understanding of subduction earthquake hazard on the Hikurangi margin, New Zealand. **Kate Clark**	*In-situ Scheelite REE geochemistry reveals evolving fluids during orogenic Otago Schist gold-tungsten mineralisation in New Zealand **Marshall Palmer**
09.45 - 10.00	The role of hydrovolcanism in the formation of the Cenozoic monogenetic volcanic fields of Zealandia **Károly Németh**	*Progress towards integrating the onshore and offshore paleoseismic record on the central Hikurangi subduction margin **Charlotte Pizer**	Structurally-focused gold deposits in the Reefton Goldfield **Mark Rattenbury**
10.00 - 10.15	Basalt karst **Bruce W. Hayward**	*Distinguishing turbidite tails from background sedimentation on the Hikurangi Margin and its implications for dating turbidites **Stephanie Tickle**	*Crucial Metals in Exposed Mantle: Ni, Co, Cu & Zn in Zealandia's Ultramafic Rocks **Stephanie Junior**
10.15 - 10.30	Linking deep crustal processes to surface uplift: a petrochronologic case study from the Transantarctic Mountains **John Cottle**	*The influence of off-fault deformation on the distribution of coseismic landslides from the 2016 Mw 7.8 Kaikōura earthquake **Colin Bloom**	Copper mobility in the near-surface environment from hematite-goethite-hosted Cu-Au mineralisation, Katoka, Zambia **Michael Gazley**
10.30 - 11.00	**10.30 - 11.00** **Morning tea** Venue: Sponsor & Exhibition Area, C-Block		

Wednesday 25 November 2020 cont.

11.00 - 13.00	8A: Geo-Teaching & Practice Geo-Education, Outreach, & International Development (GeOID) (in association with GeOID SIG)	8B: Active Tectonics Active tectonics of New Zealand - 40 years of advances	8C: Geochemistry Geochemical tools and applications to reconstruct environmental and climate change, human impact and Earth history in New Zealand, Australia and Antarctica (in association with Geochemistry SIG)
	Chair: Michael Petterson	**Chair: Kate Clark**	**Chair: Sebastian Naeher & Dan Sinclair**
	Venue: C1	**Venue: C2**	**Venue: C3**
11.00 - 11.15	Interconnected Geoscience for International Development **Michael Petterson**	Creation and destruction of Holocene marine terraces at Mahia Peninsula **Mark Dickson**	**Keynote** Effects of organic matter complexation on partitioning of transition metals into calcite: cave-analogue crystal growth studies. **Adam Hartland**
11.15 - 11.30	Abstract of a Geo-technical Advisor: Two Years Volunteering in Vanuatu **Simon Bloomberg**	Continuing on the Legacy: Marine terrace study at Aramoana, southern Hawke's Bay **Nicola Litchfield**	*Trace metal partitioning in cave (and cave-analogue) carbonate precipitates – towards a quantitative hydrological proxy in stalagmites. **Sebastian N. Höpker**
11.30 - 11.45	Engineering Geology Industry-Academia Partnerships: Experiences from the UC Quake Centre Dams Project **Clark Fenton**	The 2022 New Zealand National Seismic Hazard Model Revision **Matthew Gerstenberger**	Climatic signals in chemical weathering and soil production on New Zealand's North Island. **Claire E Lukens**
11.45 - 12.00	Assessing the merits of different educational outreach activities **Julian Thomson**	*Do large earthquakes recur regularly, randomly or clustered together in New Zealand? **Jonathan Griffin**	*Climatic effects on rapid chemical and physical denudation rates measured with cosmogenic nuclides in the Ōhau catchment, New Zealand. **Maia Bellingham**
12.00 - 12.15	**Keynote** A brief history of the GeoEd SIG **Glenn Vallender**	Variability of earthquake recurrence intervals; implications for seismic processes and hazards in New Zealand **Andy Nicol**	*Reconstructing the influence of agricultural intensification on lake ecosystem health using paleo-environmental reconstruction. **Jake Parrish**
12.15 - 12.30	GeoCamp and Tūhura Papatūānuku – engaging students with hands-on science outreach **Jess I T Hillman**	*Tectonic geomorphology and paleoseismology of the Torlesse fault, mid-Canterbury, New Zealand. **Santosh Dhakal**	Combining organic biomarker and compound-specific stable isotope records with high-resolution sediment imaging to reconstruct environmental and climate changes from New Zealand lake sediments. **Sebastian Naeher**
12.30 - 12.45	*Understanding Unrest in and around Lake Tāupo through Serious Gaming **Sriparna Saha**	*Late Holocene paleoearthquake rupture history of the Leader fault in North Canterbury prior to the 2016 Kaikōura earthquake. **Tabitha Bushell**	*Hydrogeochemical controls on the uranium isotope systematics of New Zealand rivers: Implications for the reconstruction of past ocean oxygenation changes. **Ben Perrett**
12.45 - 13.00	*Communicating the Geology of the Otago Central Rail Trail **Jenny K. Stein**	Map-view restorations of the South Island, New Zealand: a new reconstruction of the last 10 Myr of evolution of the Alpine and Wairau faults **Francesca Ghisetti**	*Biogeochemical cycling of the uranium isotope system down a permanently de-oxygenated fjord: Implications for de-oxygenation in the past oceans. **William Preston**
13.00 - 14.30	**13.00 - 14.30** **Lunch, meetings & poster viewing** Venue: Sponsor & Exhibition Area and Poster Display, C-Block		

Wednesday 25 November 2020 cont.

13.30 - 14.30	**13.30 - 14.30**					
	All lunch time meetings are located in the Ernest Rutherford Building					
	Venue: ER213	**Venue: ER219**	**Venue: ER220**	**Venue: ER221**	**Venue: ER263**	**Venue: Meet in the C-block foyer**
	GEOID SIG meeting Michael Petterson	**AusIMM Student Event: Career paths in the minerals industry - enabling a sustainable future** Michael Gazley	**Sedimentology SIG meeting** Karoly Nemeth	**Oil & Gas SIG meeting** Mac Beggs	**Palaeontology SIG/ New Zealand Fossil Record File** Catherine Reid	**Tour of the Ernest Rutherford Building** Rob Spiers

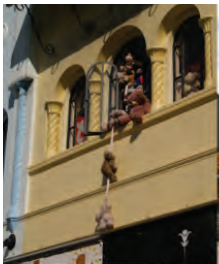
14.30 - 15.30	**9A: Geo-Teaching & Practice** **Geo-Education, Outreach, & International Development (GeOID)** **(in association with GeOID SIG)**	**9B: Active Tectonics** **Active tectonics of New Zealand - 40 years of advances**	**9C: Geochemistry** **Geochemical tools and applications to reconstruct environmental and climate change, human impact and Earth history in New Zealand, Australia and Antarctica (in association with Geochemistry SIG)**
	Chair: Michael Petterson	**Chair: Mark Stirling**	**Chair: Sebastian Naeher & Dan Sinclair**
	Venue: C1	**Venue: C2**	**Venue: C3**
14.30 - 14.45	**Keynote Speaker** Lessons learned in building virtual fieldtrip for undergraduate Geology students **James Scott**	From Edgecumbe Earthquake to today: how the initial paleoseismic studies in the Taupō Rift have shaped our understanding of active fault behaviour in the rift **Pilar Villamor**	Iti-proxy evidence for a millennial expansion of the South Pacific Gyre driven by ENSO/ SAM interactions **Daniel Sinclair**
14.45 - 15.00	Teaching science communication in the time of crisis: Updating the Auckland Volcanic Field simulation **Sophia Tsang**	Heat and mass transport in the deep TVZ **Warwick Kissling**	Informing Ramped Pyrolysis Radiocarbon Dating with Parallel Pyrolysis-GC-MS Analysis **Catherine Ginnane**
15.00 - 15.15	Covid-19 induced online sedimentology teaching: an opportunity for the integration of digital Earthscience technologies into 21st century curricula **Lorna Strachan**	Forecasting tsunamis in New Zealand using precomputed scenarios database and DART observations **Aditya Gusman**	The Forgotten Variable: Effects of sample preparation on geochemistry of invertebrate skeletal carbonate **Abby Smith**
15.15 - 15.30	What do undergraduate students gain from field experiences? A practical guide to assessment and evaluation **Alison Jolley** (Virtual)	Advances in understanding the Alpine Fault through the lens of Berryman (1975) etc. **Robert Langridge**	Earthquake-induced landsliding enhances carbon export from land to oceans over millennial timescales **Jamie Howarth**
15.30 - 16.30	**15:30 - 16:30** **Venue: C1** **Closing Ceremony & Student Awards** We will hear from Kari Bassett, Conference Convenor; MBIE; NZJGG and the 2021 Conference Committee. Followed by the GSNZ best student presentation awards.		

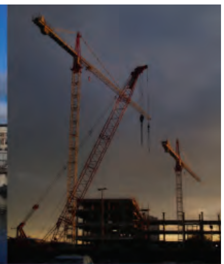
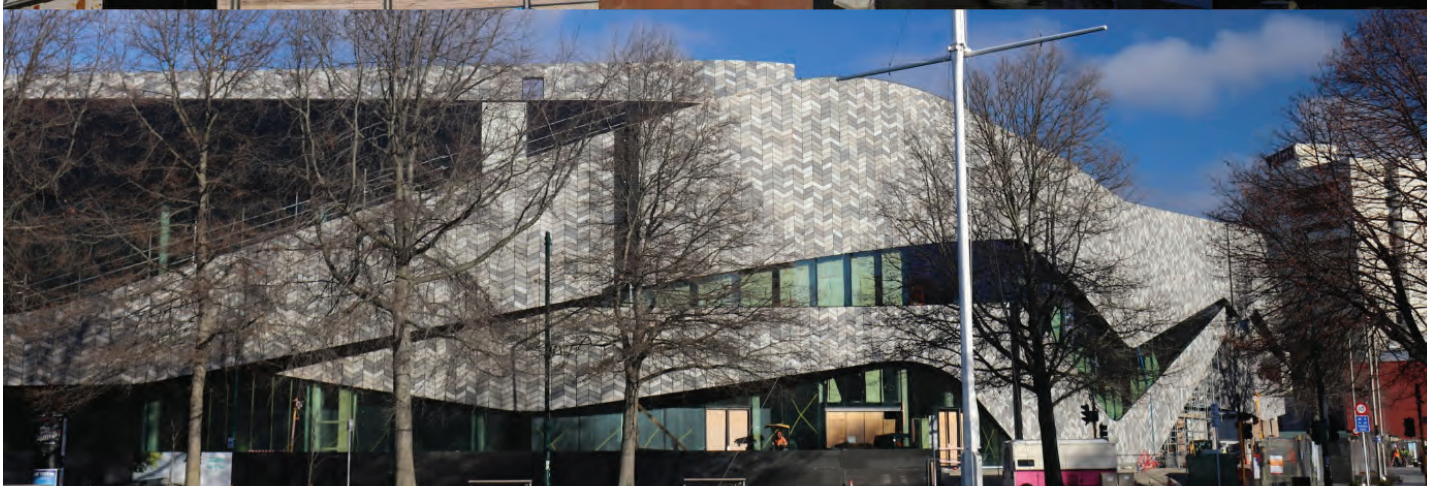
Thursday 26 November 2020

	Workshop		
	AusIMM - Placer Deposit Forum **Venue: C1 in C-Block** The forum will be chaired by Tony Christie and speakers will include Kerry Stanaway, Dave Craw, Tom Ritchie, and John Youngson		
	Field Trips		
	Petroleum exploration and production in North Canterbury Leaders: Mac Beggs (University of Canterbury), Nick Jackson (Elemental Petroleum Consultants), Bill Leask (Elemental Petroleum Consultants), Andy Nicol (University of Canterbury)	**Banks Peninsula's Best Bits: Volcanology, Research and Geopark** Leaders: Sam Hampton (University of Canterbury/Frontiers Abroad) and Darren Gravley (University of Canterbury/Frontiers Abroad)	**Walking Tour of Christchurch CBD Rebuild** Leaders: Clark Fenton (UC SEE) and Brandy Alger (UC QuakeCore)

Friday 27 & Saturday 28 November 2020

	Field Trip
	West Coast placer mineral deposits Leader: John Taylor with support from Nick Whetter, John Joungson, John Barry, John Morris, and Tom Ritchie



Poster Abstracts List

Brought to you by NIWA Taihoro Nukurangi

Monday 23 November, Poster Session 1, 17.30 – 19.00

*STUDENT POSTERS

Volcanism

1	Ian E M Smith	Intraplate basaltic volcanism in northern New Zealand: paradigms and processes
2	Kyle Bland	The new geological map datasets of the southern Auckland area
3	Leighton Watson	Using unsupervised machine learning to identify changes in eruptive behaviour at Mount Etna, Italy
4*	Sönke Stern	Kuwae: a South Pacific source of a global climate changing eruption?
5*	Lena Ray	Panitahi: long-lived cone or one-hit wonder?
6*	Nathan Collins	Geochemical insights into shallow magmatic processes and transitioning eruption styles, Ambae, Vanuatu
7*	Iseul Park	*Seismo-acoustic observations during the 2018 Ambae (Manaro Voui) eruption, Vanuatu
8*	Hanfei Wang	Petrophysical properties of pyroclastic rocks – Case-study in the Yingcheng Formation, Songliao Basin, China
9*	Henriette Bakkar Hindeleh	Short and intermediate-term precursors of phreatic and phreatomagmatic eruptions in Rincon de la Vieja volcano, Costa Rica
10	Jie Wu	Crustal evolution leading to successive rhyolitic supereruptions; lessons from the Jemez Mountains volcanic field, New Mexico, USA
11*	Ayla Stenning	The Birth of an Intraplate Volcano: Characterising the Onset of Volcanism at the Dunedin Volcano, New Zealand
12*	Boxin Li	The role of fissure eruptions and their volcanic hazard implication of the Pliocene/Quaternary Arxan-Chaihe Volcanic Field (ACVF), NE China
13*	Nessa D'Mello	Deciphering magma storage and ascent processes beneath Taranaki volcano, New Zealand, from the complexity of amphibole breakdown textures
14	Michael Rowe	Melt inclusion and mineral chemistry recording magma evolution at Mt. Taranaki
15*	Shannen Mills	Understanding how Mt Taranaki has responded to edifice collapse through eruption sequences.
16	Cynthia Werner	Detecting and quantifying magmatic tracers in spring waters on Mount Taranaki Volcano, New Zealand
17*	Cecilia Rodriguez-gomez	Characterization of surface alteration types on partially vegetated geothermal systems using hyperspectral and thermal remote sensing in combination with ground exploration techniques
18*	Gina Swanney	A blast from the past: Lithological influences on hydrothermal eruption potential, New Zealand.
19*	Michelle Fitzgerald	A Compilation and Characterisation of Lithic Populations in Maar Ejecta Rims and Diatremes
20	Rosie Cole	Testing the influence of dyke wall properties on flow localisation during fissure eruptions
21*	Brenton Tozer	Petrology and geochemistry of a suite of intrusive igneous rocks from the Kermadec Arc-Havre Trough, SW Pacific
22*	Raimundo Brahm Scott	MushPEC: Correcting post-entrapment processes affecting melt inclusions hosted in olivine antecrysts
23*	Barbara Lyon	Dissolution of crustal xenoliths at Mount Ngauruhoe as an indicator of magma residence time?
24*	Daniel A. Coulthard Jr.	The basis for chromite-melt diffusion chronometry in an oxybaro-geospeedometric context
25*	Rachael Baxter	Variable magma storage depths beneath Icelandic volcanoes - insight from revitalised OPAM barometer.
26*	Kristian Hansen	Modelling rhyolitic magma storage: a reconsideration of analytical uncertainties when using rhyolite-MELTS geothermobarometry
27*	Calvin Jones	Internal textural controls on secondary vesiculation of silicic magma
28	Graham Leonard	The ECLIPSE programme - reducing uncertainty around future unrest and eruption in the central Taupō Volcanic Zone through co-produced research
29*	David Farsky	Deep magmatic volatiles of the Taupo Volcanic Zone - insights from helium isotopes and CO2 abundance
30*	Emmy Scott	Development of a Bayesian Event Tree for Short-term Eruption Onset Forecasting at Taupō Volcano
31*	Eleanor Mestel	Initial results from an enhanced seismometer network around Taupō volcano, North Island, New Zealand
32	Finnigan Illsley-kemp	The 2019 Taupō seismic swarms reveal a stratified and active magma reservoir
33*	Carlos Rodolfo Corella Santa Cruz	Is crustal AFC responsible for felsic magma generation in the Taupo Volcanic Zone (TVZ)? Evaluating the major oxide, trace element and isotopic evidence
34	Hannah Elms	Magma ascent rates at the onset of recent rhyolitic eruptions at Okataina Volcanic Centre, New Zealand.
35*	Hannah Moore	Shallow Conduit and Vent Processes in the 1886 Basaltic Plinian Eruption at Tarawera, New Zealand

36*	Maia Kidd	Landscape evolution in ignimbrite terrains: a study of the Mamaku plateau in the Taupō Volcanic Zone, New Zealand
37	Jenni Hopkins	TephraNZ: a major and trace element reference dataset for prominent Quaternary rhyolitic tephras in New Zealand
38	Ben Kennedy	When the wiggles match: Effects of old carbon contamination on radiocarbon ages for the Changbaishan Millennium eruption, with implications for the Taupo First Millennium Eruption
39*	Yilun Shao	Microstructural characteristics of paired harzburgite and dunite bands in the Red Hills Massif, Dun Mountain Ophiolite
40	Jürgen Österle	Rapid weathering and slow erosion of an actively exhuming metamorphic core complex in tropical Papua New Guinea

Hazards

41*	Matthew Hayward	Numerical modelling of tsunami hazards posed by explosive submarine volcanism
42	Samuel Taylor-offord	GeoNet Sensor Network Capability; Estimates of the Earthquake Detectability in New Zealand
43	Muriel Naguit	GeoNet strong motion data products – modernizing & future-proofing our services
44	Jonathan Hanson	NZ DART network – updates and data access

Unravelling the seascape

45*	Laurenz Boettger	Effect of gas hydrate dissociation on seafloor stability
46	Paul Oluwunmi	The Response of Methane Hydrates to Basal Fluid Flow.
47*	Tayla Hill	A seafloor analysis at locations of known gas hydrate expulsion, Wairarapa sector of the Hikurangi Margin.
48*	Daniel King	A foraminiferal sea-level reconstruction from Pauatahanui Inlet, southern North Island, New Zealand
49	R Ewan Fordyce	Fossil dolphin diversity in the Otekaike Limestone
50*	Anthony Shorrock	How have Hikurangi margin gravity flow processes evolved from the Pleistocene to recent? Insights from IODP expedition 375, Hole U1520.
51	Marta Ribó	Predicting habitat suitability of filter-feeder communities in shallow marine environments, Queen Charlotte Sound-Tōtaranui and Tory Channel-Kura Te Au
52	Andrew Gorman	Why so deep? Seismic imaging of the sedimentary infill of Otago Harbour reveals a >150-m-deep record of Quaternary environmental change
53	Lorna Strachan	What is Project EAST?
54	Grace Frontin-Rollet	Geochemical Mapping of Aotearoa New Zealand's Marine Sediments

The cryosphere

55	Christian Ohneiser	Obliquity pacing of Antarctic glaciations during the Quaternary
56	Alena Malyarenko	Vertical mixing approaches to the ice shelf-ocean boundary layer
57*	Franz Lutz	What can borehole seismology tell us about ice anisotropy and englacial temperature in the Ross Ice Shelf?
58*	Rodrigo Gomez Fell	Fast ice over the McMurdo sound: Implications for Erebus Ice tongue dynamics.
59	Jamey Stutz	Thinning history of Byrd and Mulock Glaciers: A preliminary field report
60*	Matt Tankersley	Constrained geopotential modelling of the ocean cavity and geology beneath the Ross Ice Shelf
61*	Usama Farooq	Sea ice freeboard derived from satellite altimeter in the Western Ross Sea, Antarctica
62*	Rilee Thomas	Water chemistry and ice mechanics

Geoscience of petroleum

63*	Gabriel Meliato	A seismic reservoir characterization study of the Kora Stratovolcano, Taranaki Basin
64	Michael German	Reservoir surveillance and its impact on Māui gas-condensate field development since 1979

Poster Abstracts List

Brought to you by NIWA Taihoro Nukurangi

Tuesday 24 November, Poster Session 2, 16.30 – 17.30

*STUDENT POSTERS

Active tectonics

1*	Jaime Delano	Using historical aerial photos to estimate 2-D and 3-D displacements from the 1987 Edgecumbe earthquake, New Zealand
2*	Hamish Hirschberg	Preliminary Kinematic Model of New Zealand from Fault Slip Rates
3*	Jokotola Omidiji	Quantifying rates and patterns of erosion on newly uplifted mudstone and limestone rocks at Kaikōura Peninsula South Island New Zealand
4*	Jonathan Simpson	Weakening of Alpine Fault rocks by passing elastic waves
5	Martha Savage	Measuring the relation between changes in seismic wave speeds, geodetic displacements, and water well levels in the Wellington region
6*	Jesse Kearse	Application of Space Geodesy to Vertical Land Motion in New Zealand
7*	Jade Humphrey	Could the 1929 Ms7.8 Buller (Murchison) Earthquake have been a multi-fault rupture?
8	Jan Sintenie	A tale of two converging blocks: A new model of Neogene tectonic development for the Lake Kaniere - Lake Brunner area of the West Coast
9	Regine Morgenstern	From trees to clouds: 40 years of progress for the New Zealand Active Faults Database
10	Jennifer Eccles	Exploring Auckland Faults
11*	Hubert Zal	Spatial variations in seismic anisotropy in south-central North Island, New Zealand
12	Wanda Stratford	Crustal structure and subduction geometry in southern South Island, New Zealand.
13*	Camryn Kluetmeier	Early lichen colonization on earthquake-induced rockfalls: implications for lichenometry and its role in paleoseismic studies
14	David Barrell	Characterisation of active faults and associated hazards in relation to population centres in the Otago region

Tectonics

15	Tomek Glowacki	How positive or negative accelerations associated with Earth's motions bring to life forces which displace tectonic plates
16*	Kazuya Tateiwa	Temporal change in the rupture velocity of repeating earthquakes occurring in and around the source area of the 2011 Tohoku-oki earthquake, NE Japan
17*	Shao-jinn Chin	Preliminary seismological results of the project ITOPNC, New Caledonia
18*	Sam Treweek	High resolution gravity constraints on variations of properties across the East-West Antarctic mantle transition
19	Tim Stern	Two-staged uplift of the Transantarctic Mountains with constraints from the Cretaceous geology of southern New Zealand
20*	Steven Kesler	Reprocessing and Reinterpretation of the 1960 Gravity Survey in the Wright Valley, Antarctica and Implications for Mantle Recycling Processes

Subduction / Transition Zone

21	Wiebke Heise	Plate coupling at the northern Hikurangi margin: new results from magnetotellurics
22	Annika Greve	Strain distribution and methane migration across a shallow subduction splay fault at the Hikurangi subduction margin. A rock magnetic study on IODP Site U1518
23*	Sam Davidson	Impacts of seamount subduction on frontal accretionary and upper-plate deformation along the Northern Hikurangi subduction margin, New Zealand
24*	Weiwei Wang	Velocity variations in the northern Hikurangi margin and their relation to slow slip
25*	Olivia D Pita-Sllim	Monitoring the locked to creeping transition of the Hikurangi Subduction Zone near Porangahau using repeating earthquakes
26	Tomomi Okada	Possible involvement of overpressured fluid in multi-fault rupture inferred from seismic observations of the 2016 Kaikoura earthquake
27	Andrew Howell	Holocene vertical motions of the Kaikōura Coast
28	Trung Dung Nguyen	Centroid-moment tensor inversions using 3-D Green's tensor and adjoint method for earthquakes included in full waveform tomography of the South Island region, New Zealand
29	Emily Warren-Smith	Spatial heterogeneity in microseismicity and stress near transitional segment boundaries on the Alpine Fault
30*	Ilma Del Carmen Juarez-Garfias	Source properties of moderate-magnitude earthquakes to quantify variations in seismogenic characteristics along the Alpine Fault transitional segments.
31*	Risa Matsumura	Microstructure and chemistry of cataclasites in DFDP-1 drillcores from the Alpine Fault Zone, New Zealand

Engineering Geology

32	Clark Fenton	Recent Debris Flow Activity on Takaka Hill, Tasman District
33*	Alistair Stronach	Micro-gravity Survey of the Wellington CBD for Basin Structure and 3D Ground Motion Simulations
34*	Corinne Singeisen	How much co-seismic strain is needed for a slope to transition from incipient landsliding to debris avalanching, with reference to the Mw7.8 2016 Kaikōura earthquake

Mineral Deposits

35	Evert Durán	Interpreting Geological structures from Gravity and Magnetic data, Northland, New Zealand.
36*	Lillian Kendall-langley	Quantifying the magmatic volatile (F, Cl, S) budget of arc magmas with apatite inclusions in zircon

Climate Past and Present

37*	Levan Tielidze	Glacial geomorphology of the Ahuriri River valley, central Southern Alps, New Zealand
38*	Mikaeli Lalor	High-resolution lacustrine records of late Holocene climate change from Southern New Zealand
39*	Olivia Doyle	Distribution and abundance of foraminifera in Lyttelton Harbour/Whakaraupō.
40	Tim Moore	Palaeomires as ciphers for climate and tectonics: an example from the Early Cretaceous Hailar Basin, Inner Mongolia, China
41	Peter Almond	A paleoclimate record for the NZ extended LGM based on calcareous loess, North Canterbury - a SHeMax contribution.
42*	Emily Moore	The glacial history of Rocky Top cirque, southeast Fiordland, New Zealand.
43*	Caroline Wilsher	Paleoclimate Reconstruction of Orepuki-1 Sedimentary Drill Core: Initial Results
44	Katherine Holt	Unlocking centuries worth of surface UV-B radiation history hidden in pollen
45*	Imogen Doyle	Using pollen to investigate sediment sources in a lacustrine environment: Implications for Paleoclimate records
46	Shaun Eaves	Holocene temperature change as told by New Zealand glaciers
47	Joyce Yager	Probing mercury preservation in the sedimentary record using SEM–EDS
48	Andrew Lorrey	Revised late Quaternary glacial history of North Canterbury, New Zealand using cosmogenic radionuclide dating at Lake Tennyson
49*	Stephen Piva	The Taupō 232 CE eruption: Processes, products and an assessment of environmental impacts
50*	Ashley N. Davis	Three Centuries of Southwest Pacific Gyre Biogeochemistry Reconstructed from a New Zealand Black Coral
51*	Aidan McLean	Cosmogenic 10Be reconstructions of east coast shore platform development, NZ. Insights into the role of relative sea level.
52*	Moustapha Moussa	Characterization of tropical Soil Organic Matter by the Rock Eval-6
53*	Clarissa Ross	The Influence of Clay Mineral Properties on Expansion of Soils in Southland, New Zealand
54*	Eron Raines	Biological activity co-intensifies with rapid chemical weathering rates

Sedimentation

55*	Francisco Saldaña	Deep-marine ichnostructures and their relevance as paleoenvironmental proxies: preliminary results.
56	Cliff Atkins	A new multi-intake, high volume aeolian sediment trap

Hydrogeology

57	Leanne Morgan	Assessing the likelihood of offshore fresh groundwater in New Zealand

Geochemistry

58	Catherine Beltran	The University of Otago Organic Geochemistry Research Facility: A new Research Centre for Paleoenvironment and Paleoclimate studies focussed on the Southern Ocean and Antarctica.
59	James Scott	Natural rehabilitation of arsenic-rich historic tailings at the Alexander mine, Reefton, New Zealand
60*	Harrison Parr	Can trace metals in deep-sea corals provide information about nutrient behaviour in the waters around New Zealand?
61	Albert Zondervan	C-14 data quality assessment: A key practice at the Rafter Radiocarbon Laboratory
62	Greer Gilmer	Late Quaternary reconstruction of South Island climate using Itrax XRF elemental profiles

Geo-Teaching & Practice

63	Sophia Tsang	Home-brewed volcanoes: Virtual outreach during lockdown
64*	Kamen Engel	The emerging educational effectiveness of a virtual microscope and virtual demonstrator during the COVID-19 crisis
65	Sophie Briggs	School of rocks: engaging students in earth science and geologic heritage

PLENARY ABSTRACTS

Prediction of seismic hazards in NZ using physics-based methods: Opportunities for integration across the geosciences

Brendon Bradley[1]
[1]*University of Canterbury, Christchurch, New Zealand*

Plenary Session 3, C1, November 25, 2020, 8:00 AM - 8:30 AM

The conventional prediction of earthquake-induced hazards utilize empirical models that are calibrated directly from historical observations of the quantity of interest (e.g., ground-motion models are calibrated directly from observed ground motions). Physics-based (simulation) methods - which directly model the causative aspects of earthquake rupture, consequent ground motions, and other secondary hazards - are now reaching a tipping point where their predictive capability rivals or exceeds conventional empirical predictions for some aspects of the seismic hazard problem. The prediction accuracy and precision of such methods is also expected to continue to advance due to the 'flywheel effect' of increased data synthesis, computation, and theoretical developments.
This presentation provides a perspective on this empirical-to-physics-based prediction transition in the context of earthquake-induced ground motion prediction. Emphasis is given to the role and challenges of comprehensive validation to robustly demonstrate the predictive capability of physics-based simulations and provide confidence to end-users in the engineering community. The significant vertical integration required across many sub-disciplines in the geosciences also represents a challenge to rapid advancement; but provides a natural framework within which significant integration and collaboration among these disciplines can occur.

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Ability not gender: New Zealand women geologists in Antarctica

Margaret Bradshaw[1]
[1]*University of Canterbury, Christchurch, New Zealand*

Plenary Session 2, C1, November 24, 2020, 8:00 AM – 8:30 AM

Attitudes have changed towards women in Antarctica since 1969. What were the lengths women had to go before being accepted in a "man's world"? Constructive attitudes were expressed by both the men and the women in mixed parties. The first woman to go south was zoologist Pam Young in 1969 who assisted her husband with his Skua studies. In 1970 Rosemary Askin (now Kyle) was a single woman in a 5-person Victoria university party that found important fish fossils. She returned the following year, this time for plant fossils.
In 1975 I went to Antarctica to collect specimens for new displays at Canterbury Museum and was joined by a British woman, a story in itself. The following year, I made a detailed study of the rich ichnofauna of the Devonian Taylor Group in the Dry Valleys, accompanied by a tolerant mountaineering field assistant.
My work on New Zealand Devonian rocks inspired me to organise a mixed 4-person deep field party to the Ohio Range to compare faunas, becoming one of NZ's remotest deep field parties. This demanded a lot of planning but was highly successful. In 1983-84 I returned to this locality with a different party to study Devonian trace fossils and younger glacial and plant bearing beds, including coals.
A sledging season in the Darwin Glacier area in 1988-89 to investigate animal traces in Devonian sediments, located a new, fossil fish locality. In 1991-92 I led a fish-collecting team, completing a 700km traverse of the Cook mountains north to Mt Crean.
In 2004, 2006 and 2008, I was involved in Devonian Beacon sedimentological and provenance studies from Mt Suess in the north, though the Dry Valleys to Rotunda in the south, focusing on the Heimdall Erosion Surface and the basal deposits of the Taylor Group.

margaret.bradshaw0@xtra.co.nz

Braiding geoscience and mātauranga Māori: the case for a trans-epistemological approach

Clare Wilkinson[1]
[1]*University of Canterbury, Christchurch, New Zealand*

Plenary Session 1, C1, November 23, 2020, 10:30 AM – 11:00 AM

Both cultural and physical landscapes are altered significantly in response to geological processes. As Earth scientists in Aotearoa New Zealand, we have both the obligation and opportunity to consider these landscapes and processes through the lenses of science and Te Ao Māori. Mātauranga Māori (the knowledge, worldview, values, culture and practices of the Indigenous peoples of Aotearoa) has, to date, been poorly represented within geomorphological investigations despite clear linkages between scientific and traditional knowledge of Earth surface processes. In this talk, I will explore frameworks for bicultural research in geomorphology and provide case studies from the 2016 Kaikōura earthquake and from across Aotearoa New Zealand that highlight how mātauranga Māori can inform and focus geomorphological investigations and ensure that the science of Earth's surface meets the needs of society.

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ABSTRACTS

Abstracts are ordered alphabetically by the surname of the first author. The name of the presenting author is underlined and their email address is given immediately below the abstract.

Stabilizing and readvancing the grounding line of Pine Island Glacier

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2C: Cryosphere, C3, November 23, 2020, 1:30 PM - 3:30 PM

Pine Island Glacier is among the most extensively studied glaciers in the world, because of its recent high rate of mass loss, its large catchment size, fast flowing ice trunk and sensitivity to ocean forced melting. The glacier is grounded on bedrock below sea level that deepens inland, meaning that as the grounded area diminishes through ocean forced retreat, the flux of ice that is discharged into the ocean increases, exacerbating the contribution to sea level rise. Although the velocity trend over the satellite period indicates that the glacier has been accelerating, recent studies have also shown periods of deceleration. Here we present an ensemble of 200 year simulations of Pine Island Glacier forced with varying oceanic melt rates. We use a high resolution adaptive mesh ice sheet model to robustly capture grounding-line migration, and initialise the model from observations of present day ice thickness and surface velocity. Starting with a present day initial configuration of the glacier, we increase ice shelf basal melt rates for fixed periods that range from 20 to 100 years, then abruptly remove this forcing in order to explore the ability of the ice stream to stabilise. In all of our modelled scenarios we observe 24 km of grounding line retreat, despite the differences in cumulative melt forcing. Since the scale of retreat appears to be independent of the external forcing applied, we next reduce sub-shelf melt rates below initial conditions to quantify the melt rate threshold required to readvance Pine Island Glacier to its current position. Our results also show that a reduction in melt rate forcing to levels far below present-day values is required to substantially reduce the glaciers positive contribution to sea level rise.

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A paleoclimate record for the NZ extended LGM based on calcareous loess, North Canterbury - a SHeMax contribution.

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

We have derived a high resolution record of climate and environmental change on the east coast of the South Island for the New Zealand extended last glacial maximum (eLGM) from loess near Waipara, in North Canterbury. The local geology contributes a calcareous component to the dominantly quartzofeldspathic loess, which results in high soil pH and a soil environment which preserves calcareous subfossil material. Moa egg shell and terrestrial gastropod shells in the loess provide a proxy of primary productivity and aridity, and a high resolution radiocarbon chronology, something previously very difficult to attain from NZ loess. The period of time from Kawakawa tephra (25.4 k cal y B.P.), which occurs cryptically in the section, to 21 k cal. y B.P. is represented by up to 2.5 m of loess. Gastropod and moa egg shell distribution together with loess grain size data indicate a period of humidity, waning wind speed and higher primary productivity in the period 25.4 to 24 k cal. y B.P.. From 24 to 22.5 k cal. y B.P. the environment became less productive and windier. From 22.5 ka to 21 ka conditions ameliorated as inferred from an increase in frequency of gastropod shells, although shells were smaller than the zone below and moa egg shell did not reappear. This climate structure through the eLGM is consistent with that defined by the NZ Climate Event Stratigraphy, which is based on a pollen record from south Westland. The interstadial event from 25.4 to 24 k cal. y B.P. (NZce9 – Otira interstadial event D) manifests as warming and increasing precipitation both east and west of South Island. This pattern, and responses of coastal Antarctica, lead us to suggest the event corresponds to a waning of westerly winds and migration of the oceanic subtropical front southwards.

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Constraining the age and depositional processes of Taylor 2 Drift with cosmogenic nuclides in Pearse Valley, Antarctica

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5C: Climate, C3, November 24, 2020, 11:00 AM - 1:00 PM

During the last interglacial (Marine Isotope Stage (MIS) 5e), outlet and alpine glaciers in the Dry Valleys region appeared to advance in response increased open ocean in the Ross Sea. However, the timing and extent of antiphase behaviour between outlet and alpine glaciers in the Dry Valleys region, and ice in the Ross Sea is poorly resolved. Here, we document retreat of a peripheral lobe of Taylor Glacier in Pearse Valley, an area that was glaciated during MIS 5. First, we measured cosmogenic ^{10}Be and ^{26}Al in 3 granite boulders from thin, patchy drift (Taylor 2 Drift) in Pearse Valley to constrain the timing of retreat of Taylor Glacier, or subsequent till deflation. Our data indicates either Taylor Glacier had only partially retreated from Pearse Valley by 70 ka or till deflation was occurring at this time. Timing of retreat after 70 ka, until the Last Glacial Maximum, where Taylor Glacier was at a minimum position, remains unknown. Second, we measured companion ^{10}Be and ^{26}Al depth profiles of permafrost to relate the depositional processes between surface boulders and underlying permafrost sediments. Depth profile ^{10}Be concentrations range from 3.8 to $4.4 \pm 0.1 \times 10^6$ atoms g^{-1} with a mean of $4.1 \pm 0.1 \times 10^6$ atoms g^{-1}. The absence of an attenuating depth profile suggest that these sediment repositories are too young for the most recent exposure (<100 ka) to alter their inherited ^{10}Be concentration, achieved through the recycling of sediments over multiple glacial cycles. These results indicate that thin, patchy drift comprising surface boulders and underlying permafrost sediments in Pearse Valley were deposited as melt-out and waterlain tills following MIS 5 advance of Taylor Glacier.

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Linking deep crustal processes to surface uplift: a petrochronologic case study from the Transantarctic Mountains

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7A: Volcanism, C1, November 25, 2020, 8:30 AM - 10:30 AM

The processes that drive formation of elevated topography in regions undergoing lithospheric-scale extension remain a matter of significant debate. Although geophysical data provide important modern observations, direct constraints on the thermal and mechanical state of the deep crust through time are necessary to understand how these systems develop. This study focuses on an archetypal ‘rift shoulder' uplift, the ≃3,500 km long and >4 km high Transantarctic Mountains (TAM) that divides East and West Antarctica. Multimineral petrochronology of granulite xenoliths entrained in <1 Ma rift basalts along the TAM front documents the Cenozoic thermal history of the lower crust beneath the TAM, and provides a direct link between deep crustal processes and the surface evolution of this enigmatic mountain belt. Laser Ablation Split Stream (LASS) analysis of zircon, titanite, rutile, and apatite record heating of the deep crust to ultra-high temperature conditions that were sustained from the mid-Cenozoic through to the time of eruption during a period of major rifting and exhumation of the TAM. Accessory phase geochemistry additionally documents recrystallization and growth during an influx of externally-derived high-SiO_2 melts during rifting. Our data indicate that formation of the TAM occurred as a result of thermal-weakening of the deep crust during rift-related heating which drove crustal excision and resulted in upper crustal exhumation and surface uplift.

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A new multi-intake, high volume aeolian sediment trap

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Wind-blown sediment in high latitude regions (>40°) is important because it can have a disproportionately large impact on marine and terrestrial ecosystems. However, trapping aeolian sediment in these regions remains challenging due to infrequent sample recovery opportunities and harsh environmental conditions. We present a new robust, multi-intake aeolian sediment trap designed for long deployment in remote locations. Our custom-built trap comprises three 1m long, 150mm diameter sections of plastic pipe bolted together to form a vertical tower. Each section has 12 litre capacity sump and a fixed direction, 50mm diameter intake which are located at 0.3, 1.0 and 2.0 m above ground respectively. The tower is mounted in an 0.4 m deep hole and secured via guy wires. The intake design is based on the widely used SUSTRA (Suspended Sediment Trap). A tower trap was deployed on the braid plain of the Hopkins River, which feeds Lake Ohau, from October 2018 to April 2019, close to a weather station recording wind velocity. The trap performed well, collecting large samples and withstood wind events in excess of 140km/h and shallow (<30cm) surface flooding. Samples recovered from the tower trap show an expected logarithmic decrease in mass of sediment from 2.6kg in the lower trap to 0.92kg in the top trap. Laser particle size analysis shows modal grainsize decreases from of 223µm (fine sand) in the lower trap to 85.5µm (very fine sand) in the top trap along with an increase in the percent silt and sorting above ground. X-ray florescence analysis yielded major element composition consistent with Torlesse greywacke provenance.
These preliminary results indicate the tower traps effectively sample the vertical profile of suspended aeolian sediment. The traps are robust, easy to deploy, ideal for long deployment and can handle high volumes of sediment and snow transport.

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Short and intermediate-term precursors of phreatic and phreatomagmatic eruptions in Rincon de la Vieja volcano, Costa Rica

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Rincon de la Vieja volcano is the only active in the Volcanic Range of Guanacaste, located in Costa Rica. After 13 years of no eruptive activity, several phreatic eruptions occurred in September 2011, which generated small hot lahars into the north region of the Active Crater. In the following years, the eruptive activity remained intermittent and increased in 2014 to 2017, when a phreatomagmatic eruption occurred with pyroclastic flows and descending hot lahars. The general evolution of seismicity in terms of time-frequency analysis is applied to establish the main changes that have occurred during the study period and to relate them to the eruptive activity. These patterns allow us to understand the volcano dynamics, and recognize common precursors in short and intermediate-term eruptive activity. The methodology comprises various signal processing techniques that are based on the Fast Fourier Transform (FFT) combined with autoregressive modeling. We examined seismic-volcanic signals with a strong harmonic signature, as is the case of “tornillo” type signals. These signals possess characteristics of the resonance source that originates them, such as the frequency and the associated quality factor (Q). Nakano et al. (1998), Kumagai & Chouet (1999, 2000) showed the usefulness of these methods in order to determine the acoustic properties of volcanic fluids. The temporal variation of the Q factor makes it possible to study the evolution of these characteristics and thereby understand the evolution of the eruptive dynamics. These waveforms are associated with intermediate-term precursor (several months before). However, the common long period signals and spasmodic tremor in the band frequencies from 1 to 10 Hz appear as the first short term precursors (less than 48 hours before) of eruptions with the highest seismic energy.

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Investigating the seasonal dynamics of the Ross Ice Shelf, Antarctica using remote sensing data

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2C: Cryosphere, C3, November 23, 2020, 1:30 PM - 3:30 PM

Currently, it is important to predict the impact global warming will have on the future of the global ice sheets and their contribution to sea-level rise. The Ross Ice Shelf (RIS) buttresses both the West Antarctic Ice Sheet (WAIS) and the East Antarctic Ice Sheet and thus has a strong potential to control future sea-level rise (Rignot et al. 2013). Rapid deglaciation of the WAIS remains a primary uncertainty in sea-level rise projections due to an incomplete understanding of ice sheet processes, unknown future anthropogenic emissions and the internal variability of climate forcing (Pattyn and Durand, 2013; Robel et al., 2019). Understanding the processes that control RIS dynamics today can help interpret ice sheet changes due to atmospheric and oceanic warming that occurred in the past (Lowry et al. 2019) as well as what is projected for the future (Dinniman et al.2016).

This project aims to use remote sensing and fieldwork to better characterise short-term environmental variability in RIS dynamics, because the sensitivity of the Antarctic Ice Sheet system to internal environmental varaibility - as opposed to externally-forced large-scale climate perturbations - remains poorly understood and constrained (Gwyther et al. 2018; Holland et al. 2019). Remote sensing data can provide invaluable insights into Antarctica's ice flow rates and mass loss (Rignot et al. 2013; Mouginot et al. 2017), and this has led to improvements in ice sheet model initializations and parameter estimation (Pattyn et al. 2017). This presentation will present satellite and GPS ice velocity estimates for the RIS, and will compare these to observations of oceanic and atmospheric changes. Methodological as well as seasonal differences in ice velocity magnitudes will be discussed in the context of their ability to constrain ice sheet model simulations that explore how ice shelf behaviour may be influenced by short-term environmental forcing.

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An eruption in search of a volcano? The evidence at source for the mid-15th century Kuwae event

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4B: Hazards, C2, November 24, 2020, 8:30 AM - 10:30 AM

The mid-fifteenth century eruption of the Kuwae volcano, often claimed as one of the three largest sulphate events of the Common Era, remains controversial in terms of its precise date, scale and global signature. This controversy stems largely from uncertainty around the description and characterisation of the eruption at source, in what is now Vanuatu. Through a comprehensive survey of the literature, we present review the archaeological, volcanological and historical evidence for the Kuwae eruption, in order to address three questions: What level of confidence can we have in current understandings of the Kuwae event? What are the particular gaps in knowledge that require attention through further research? And how might a multi-disciplinary approach tackle
these questions, drawing on volcanology, archaeology and history, along with linguistics, palaeo-ecology and seismology? This review underpins a new field research program that aims to provide answers to each of these questions, while also working closely with the communities resident in islands around the volcano to develop locally appropriate disaster risk reduction measures. An exceptional feature of the Kuwae eruption is its centrality in local oral tradition, which details the fates of numerous named individuals, and their eventual recolonisation of the remnant islands of Epi and Tongoa. This unusual access to a long history of Indigenous risk management strategies, which continue into the present, provides a platform for contemporary protocols that foreground the experience of communities resident around the volcano.

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Taupō: what we know (and don't know) about New Zealand's youngest supervolcano

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5A: Volcanism, C1, November 24, 2020, 11:00 AM - 1:00 PM

Lake Taupō in the central North Island is New Zealand's largest freshwater lake, a popular tourist and fishing destination, and the site of one of Earth's most frequently active and potentially hazardous caldera volcanoes. The Taupō area has produced eruptions of a wide variety of sizes, styles and associated impacts over a ∼350 kyr period that provide insights into its evolution. Here I will discuss our understanding of Taupō's magmatic history, based on combined field, petrological and geochemical studies, with implications for how we might interpret recent seismicity and the modern-day state of the volcano. Taupō's history can be split into three distinctive periods. Early Taupō (>54 ka) is represented by widely scattered, geochemically distinct domes and explosive eruption products from vents under and around the modern lake and merging with Maroa to the north. From 54–25.5 ka, Taupō had two independent magmatic systems, one focused beneath the area of the modern lake and a second, northeast of the lake that has remained active to the present day. At ~25.5 ka Taupō produced the youngest known supereruption on Earth which ejected >1100 km^3 of pumice and ash during the Oruanui event, resulting in caldera collapse and widespread destruction. Following the Oruanui supereruption, the rebuilt modern hyperactive Taupō magmatic system has been primarily focused beneath the lake and has generated 25 rhyolitic eruptions since ∼12 ka. The young rhyolite magmas come from an evolving silicic magma reservoir, but vary widely in their eruptive sizes and destructive potential. In the modern era Taupō experiences unrest every decade or so, which reflects a highly active magmatic system that is capable of producing another significant eruption. Continuing research aims to provide knowledge of the location and state of Taupō's magma reservoir and the processes that will lead to future unrest and/or, ultimately, eruption.

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Bye Bye, Bipolar Seesaw?

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6C: Climate, C3, November 24, 2020, 2:30 PM - 4:30 PM

Dating of glacial moraines in the central Southern Alps has furnished a rich record of the timing of maximal glacier extent during the Last Glaciation (~65 to ~18 ka), subsequent glacier recession, glacier extents during the late glacial interval (~15 to 12 ka), and Holocene glacier variations (<12 ka). Rapid warming across southern New Zealand began ~18 ka and near-interglacial conditions were attained within ~1500 years. Similar signatures occur in South America and are emerging from well-resolved Northern Hemisphere glacier moraine chronologies. The last glacial termination and late-glacial variations appear to have been synchronous globally.

The Milankovitch model invokes an orbital control on the extent of Northern Hemisphere continental ice sheets, with that signature transmitted globally via ocean/atmosphere to produce approximately synchronous glacier behaviour, despite opposing southern orbital forcing parameters. An alternative hypothesis proposes a primary influence of orbital variation on the austral westerly winds and the Southern Ocean. The Zealandia continent is a physical keystone in that system, determining whether the coupled austral westerlies/Subtropical ocean front direct outflow from the Indo-Pacific warm pool north (glacial mode) or south (interglacial mode) of New Zealand. Modelling demonstrates that global climate effects arise from the latitudinal position of the austral westerlies. Via that mechanism, millennial-scale climate episodes such as Heinrich stadials were caused by southern-sourced global warming producing enhanced melt of northern ice sheets, extensive winter freezing of a freshened North Atlantic Ocean and resulting extreme northern seasonality of severe winters and mild summers. In that view, the millennial bipolar seesaw was an inter-regional northern effect produced by southern-sourced global climate forcing.

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Characterisation of active faults and associated hazards in relation to population centres in the Otago region

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The impact of the 2010 Darfield Earthquake and its aftershocks on the greater Christchurch area has raised general awareness of the potential significance of active faults close to population centres. The GNS Science Urban Geological Mapping project is compiling suites of geological data products for selected urban areas in New Zealand, and the question of active faults and associated hazardous impacts is of high interest to urban communities.

Initiated by Canterbury Regional Council in 2008, GNS Science has completed a series of district-by-district projects reviewing and updating data on Canterbury’s active faults. This initiative was subsequently extended by Otago Regional Council, with work on Otago’s active faults completed in 2020. Thematically aligned recent government-funded initiatives in the wider Dunedin area included an investigation of whether there are any hidden faults near the city (Villamor et al. 2018; GNS Miscellaneous Series 124), and a paleoseismic investigation of the Titri Fault, one of the more prominent in coastal Otago and passing under some satellite suburbs of Dunedin (Barrell et al. 2020; GNS Science Report 2017/35).

Urban geological mapping in Otago currently focuses on the Queenstown, Wanaka and Dunedin areas. No active faults are known at Queenstown. The NW Cardrona Fault passes under Wanaka township, contrary to previous interpretations, with suspected recurrence interval between ~5,000 to ~10,000 years and timing of most recent surface rupture uncertain. Near Dunedin, the Titri Fault passes under the Mosgiel suburb and is confirmed as active, with recurrence interval between ~10,000 to ~20,000 years and most recent surface rupture >~18,000 year ago. Data indicate that contrary to previous suggestions, the active Akatore Fault does not extend under Dunedin, but a potentially active fault (Kaikorai Fault) is suspected to pass under part of the city but has no known recent activity and probably a long recurrence interval (>20,000 years).

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Variable magma storage depths beneath Icelandic volcanoes - insight from revitalised OPAM barometer.

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Petrological tools provide fundamental constraints on the nature of magmatic plumbing systems. Well defined and calibrated barometers, with robust understanding of their limitations and uncertainties, are one petrological tool with which to interrogate the structure and magma storage depths of volcanic systems. However, published barometers can easily be misused when applied to natural systems, presenting a serious problem for the reliability of the petrological contributions to studies of volcanic systems. One example is the Olivine-Plagioclase-Augite-Melt (OPAM) barometer. OPAM was developed for analysis of Mid-Ocean Ridge Basalts (MORB), co-saturated with olivine, clinopyroxene and plagioclase [1]. The parameterisation of OPAM is based on multivariate linear regression of experimental data. Ca, Al and Fe are expressed as functions of pressure and other melt components. These equations track the boundary of the OPAM eutectic. Previous use of this barometer has failed to process and filter out glass samples unlikely to have been co-saturated with olivine-plagioclase-clinopyroxene, producing erratic, unreliable results. Furthermore, widely used realisations of this barometer were based on the rearrangement of these expressions, which is prohibited by the mathematics of regression.
We used the original regression result to cast this problem as one of misfit minimisation, allowing us to access the reliability of fit, then eliminate samples far from OPAM saturation. When we applied this approach to a dataset of 255 experimental glass compositions, we determined OPAM has a mean average error of 1.16 Kbar. This barometer was then applied to a large data set of Icelandic glass compositions, generating an updated perspective of magma storage depth distributions beneath Icelandic volcanoes.

[1] Yang, H.-J. et al., 1996, Contributions to Mineralogy and Petrology, 124, 1-18.

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Nimbyism in Marlborough - Reconsenting Barracks Quarry

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7C: Minerals, C3, November 25, 2020, 8:30 AM - 10:30 AM

In 2011 consent was granted to Simcox Construction Ltd to increase production from Barracks hard-rock quarry near Blenheim to 90,000 tonnes per annum. This followed an appeal to the Environment Court by local residents, and expert evidence was required to assist the quarry operator. Barracks Quarry rock is a low porosity sandstone of the Pahau Terrane with widely spaced jointing, and is well suited to both aggregate and armourstone production. Armourstone usage for both river bank protection and coastal/harbour works has become critical in Marlborough.

Because the consent term was only eight years, renewal application was required again in early 2020 with further local opposition. On this occasion the importance of Barracks armour rock was emphasised in evidence, and the consent renewal for a 25 year period was granted in September 2020. The case study illustrates ways that the Resource Management Act can be manipulated by objectors to delay (and even stop) necessary infrastructure options for local communities. Some 10 experts were required to give evidence at significant cost to the quarry.

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Building on Difficult Ground - Two Case Studies

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5B: Engineering Geology, C2, November 24, 2020, 11:00 AM - 1:00 PM

The first case study is the development of a large residential subdivision on peat and clay-rich soils in the northern part of Christchurch, which has been progressing since 2013. The generalised ground model comprises overbank silts and sands, swamp-derived peat layers interbedded with silty clays, and Last Glaciation Riccarton Gravel between 13 and 16m below existing ground. Development of infrastructure and house sites has adopted a 'raft' method whereby approximately 1m of engineered gravel fill is placed after topsoil removal. Deeper buried pipe networks may require sheetpiling for installation, and railway ballast support has been adopted for bearing and drainage. The groundwater is complex and layered, with a sand unit between 8 and 9m deep having an artesian head above ground level. The site has not been subject to liquefaction, but consolidation-induced settlement in peat and clayey soils requires pre-load and monitoring. The integrity of the 'clay cap' is critical.

The second case study involves residential development on and immediately adjacent to the Coronet Peak Landslide near Arthurs Point, Queenstown. The Coronet Peak Landslide has a volume in excess of 1,000 million cubic metres, extending from valley floor to ridge crest, and is developed on pelitic schist of the Rakaia Terrane. Toe modification by ice during the Last Glaciation is evident, and a series of late to post-glacial Shotover River terraces are preserved. Extensive subdivision is taking place at Arthurs Point, and consent was recently granted for cluster development with beech reforestation above the settlement. House construction requires site-specific foundation investigation and stormwater control, as well as spring management and localised toe dewatering.

The two case studies provide examples of the role of engineering geology in residential development on difficult ground, and the critical importance of understanding site hydrogeology. Ground models and monitoring are much more important than numerical modelling.

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Climatic effects on rapid chemical and physical denudation rates measured with cosmogenic nuclides in the Ōhau catchment, New Zealand

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8C: Geochemistry, C3, November 25, 2020, 11:00 AM - 1:00 PM

Understanding how active mountain landscapes contribute to carbon dioxide cycling and influences on long-term climate stability requires measurement of weathering fluxes from these landscapes. In the Southern Alps, New Zealand's rapid tectonic uplift coupled with extreme orographic precipitation is driving exceptionally fast chemical and physical denudation. These high rates of weathering suggest the Southern Alps could play a significant role in carbon dioxide cycling. However, the relative importance of climate and tectonics driving these fast rates remains poorly understood.

To address this gap, in situ ^{10}Be derived catchment-averaged denudation rates were measured in the Ōhau catchment, Canterbury, New Zealand. Denudation rates in the Dobson Valley within the Ōhau catchment, varied from 474 – 7,570 m Myr^{-1} , aside from one sub-catchment in the upper Dobson Valley that had a denudation rate of 12,142 m Myr^{-1} . The Dobson and Hopkins Rivers had denudation rates of 1,660 and 4,400 m Myr^{-1} respectively. Dobson Valley denudation rates show a moderate correlation with mean annual precipitation (R^2=0.459). This correlation supports a similar trend identified at local and regional scales, and at high rates of precipitation this may be an important driver of erosion and weathering.

Chemical depletion fractions measured within soil pits in the upper Dobson Valley indicate chemical weathering contributes 30% of total denudation, and that physical erosion is driving rapid total denudation. Chemical weathering appears to surpass any proposed weathering speed limit and suggests total weathering may not be limited by weathering kinetics. This research adds to the paucity of research in New Zealand, and for the first time presents ^{10}Be derived denudation rates from the eastern Southern Alps, with estimates of the long-term weathering flux. High weathering fluxes in the Southern Alps uphold the hypothesis that mountain landscapes play an important role in carbon dioxide cycling and long-term climate stability.

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The University of Otago Organic Geochemistry Research Facility: A new Research Centre for Paleoenvironment and Paleoclimate studies focussed on the Southern Ocean and Antarctica.

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The new Organic Geochemistry Research Facility is an interdisciplinary research group gathering marine science researchers, geologists, geographers and chemists who study past and recent sea surface temperatures, ocean currents and wind patterns with a special focus on the Southern Ocean and Antarctica regions. Our group also includes social anthropologists and anatomists who have a special interest in identifying organic molecules in archaeological remains to characterize plant use and environmental modifications in Melanesia.

The key instruments of the research facility are chromatographs including Gas Chromatograph with a flame ionization detector (GC-FID) and a Mass Spectrometer (GC-MS) and a High-Performance Liquid Chromatograph (HPLC-MS).

This facility will be used to characterize organic compounds extracted from natural sediment samples and archaeological artefacts.

The research facility is (and will be) used in the following broad, cross-departmental research fields:
- Reconstructing Ancient ocean temperatures from sediment cores: Alkenone unsaturation ratios, TEX86, Long Chain Diols.
- Reconstructing past Antarctic sea-ice conditions from sediment cores: Highly branched isoprenoids.
- Reconstructing wind, rainfall and plant communities in prehistoric New Zealand from lake and fjord sediments: N-alcohols and n-alkanes.

By measuring the abundance and H stable isotope composition of compounds derived from terrestrial vascular plants it is possible to reconstruct how atmospheric circulation and plant communities have changed over time.
- New organic molecular proxy development

We are working towards identifying new organic biomarkers for ocean temperature reconstructions at high latitudes. This work is in its infancy but includes proxy development from marine diatom cultures for ocean temperature reconstructions.
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Reflections on advances in active tectonics in New Zealand in the past 40 years

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7B: Active Tectonics, C2, November 25, 2020, 8:30 AM - 10:30 AM

In the mid 1970's the NZ Geological Survey (NZGS) view was that there was no proven Holocene strike-slip movement on the Alpine Fault south of Hokitika and the Hikurangi Subduction Margin was aseismic. This conservative view was not universal. Harold Wellman had already published on river deflections across the Alpine Fault in south Westland, and historic coastal uplift and coastal geomorphology in Wairarapa and Hawkes Bay also hinted at seismic coupling in the subduction margin. No paleoseismic trenches had been opened and radiocarbon dating required samples of several hundred grams weight in the era prior to Accelerator Mass Spectrometry (AMS).
Substantial progress has been made in the four decades since then! When I joined NZGS in November 1974 many of the main active faults had been identified using aerial photographs, and areas of coastal uplift and subsidence were known. So, the 'where' was in reasonably good shape, but the 'what' and the 'when', which are prerequisites for quantified hazard and risk, were in their infancy.
Four key things underpinned the progress, in my view. Firstly researchers (myself included), exposed to plate tectonics teaching, wanted to understand rates of tectonic motion, landscape evolution and hazard. Secondly, geodetic observations were recording contemporary rates of deformation (theodolites, precise levels initially) and then GNSS. Thirdly, trenching across faults greatly accelerated the understanding of the timing and size of large earthquakes associated with past surface fault ruptures. And fourthly, AMS radiocarbon capability at the Rafter Radiocarbon Lab from 1987 greatly enabled paleoseismic studies.
Next generation remote sensing using Lidar, InSAR and differential aerial imagery, new and improved dating techniques, and deformation models integrating diverse datasets to investigate time-varying processes sees us on the cusp of another great step in active tectonics research in New Zealand and its application in managing future natural hazard risks.

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Volcanoes Buried in Te Riu-a-Māui/Zealandia Sedimentary Basins

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4A: Volcanism, C1, November 24, 2020, 8:30 AM - 10:30 AM

Many volcanoes are buried within Te Riu-a-Māui/Zealandia sedimentary basins. Over the last 150 years, geological mapping and studies of igneous rocks from onshore and offshore New Zealand, New Caledonia and several surrounding small islands have provided an enormous amount of information about volcanic activity in Zealandia. However, to date, few studies have had incorporated detailed information from volcanoes buried within Zealandia sedimentary basins. Based on a large collection of seismic reflection and drillhole data, this study outlines the morphology, location and age of over 400 volcanoes buried in offshore New Zealand, ranging in age from Late Cretaceous (ca 105 Ma) to Pleistocene (ca 1 Ma). We established a systematic classification of these volcanoes into three large-scale categories (i.e. rift, intraplate, and subduction-related). These categories are sub-divided into informal volcanic zones, fields, complexes, and individual volcanic edifices, according to their location, distribution, age, size and morphology. Late Cretaceous volcanism mainly formed large (>20 km3) composite cones and volcanic complexes that erupted along rift faults related with the break-up of Zealandia from south-eastern Gondwana. Cenozoic intraplate volcanic activity was widespread, typically forming clusters of scattered small-volume (<1 km3) craters and cones. In contrast, large Cenozoic volcanic complexes, composite cones and shield volcanoes erupted along linear arcs associated with subduction along the Pacific-Australian plate boundary. In detail, the presence of pre-existing structures and types of host-rocks also influence the passage of magma in the shallow (<5 km) crust and the location of eruptive centres, regardless the tectonic setting of eruptions. This study showcases the utility of seismic reflection for determining the relationship between volcanic and tectonic activity. Studying the volcanoes buried in sedimentary basins can help advance understanding of syn- and post-Gondwana break-up magmatism, with global impacts to comprehend the interplay between volcanism and plate tectonics in Zealandia and further afield.

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The new geological map datasets of the southern Auckland area

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

GNS Science's 'Northern Cities' workstream of the Urban Geological Mapping project is finalising a suite of digital data products encompassing the southern Auckland-northern Waikato area, extending from the southern Manukau Harbour to the lower Waikato River, and from Āwhitu Peninsula to the western side of the Hunua Ranges. The area encompasses the population centres of Waiuku, Pukekohe, Drury, and Papakura, and is undergoing significant urban and infrastructure development. The suite of new data products provides a robust framework to assist and guide geological and geotechnical investigations in this area.

A new lithostratigraphic framework for the Auckland region's Plio-Pleistocene sedimentary strata has been developed in consultation with local geological and geotechnical practitioners (Barrell et al. 2020; GNS Science Report 2020/05). Strata hitherto described as "Puketoka Formation/Tauranga Group" are encompassed by the new Takanini Formation. Lithological variations are encapsulated by 8 lithofacies-based non-age-specific members.

These strata, and other units of Mesozoic to Holocene age, are being mapped at 1:50 000 on an updated geological map (Bland *et al*., forthcoming). Underpinning and enhancing the geological map is a new 1:50 000 geomorphological map, which characterises the various landform features (Townsend *et al*., forthcoming). The sub-surface geology will be represented in a new 3D geological model, utilising an extensive volume of open-file borehole data and aeromagnetic geophysical data (Hill *et al*., forthcoming).

Highlights of these new products include:

- More detailed and refined mapping of features within the South Auckland Volcanic Field, including differentiation of tuff rings, lava flows, and cones;
- Categorization of the nature and origin of landform features;
- The identification and mapping of than 600, mainly prehistoric, landslides, mostly in the Hunua Ranges and Pokeno area;
- Delineation of several fault scarps, some of which may potentially be classifiable as active faults.

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After the Cretaceous Cenozoic Research Project: 25 years of research and discovery in New Zealand's sedimentary basins

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3C: Petroleum, C3, November 23, 2020, 4:00 PM - 5:30 PM

The last 25 years has seen a step-change in the volume of data and understanding of New Zealand's extensive offshore estate, driven primarily by 1) the UNCLOS programme, which worked to delineate the official geological limits of New Zealand's offshore realm, and 2) a Government focus on the discovery and unlocking of the nation's petroleum endowment for economic gain.

Government-funded regional-scale seismic reflection surveys from the mid-2000s onward significantly advanced knowledge of known basins (e.g., East Coast) and led to the discovery or delineation of new sedimentary basins (Deepwater Taranaki, Pegasus, Raukumara). Increased partnerships between CRIs and Government departments (e.g., GNS and NZP&M), supported by underpinning geoscience datapacks, facilitated international promotion of NZs petroleum potential. The arrival of major exploration companies delivered a near-unprecedented level of frontier basin exploration, with a dramatic increase in geoscience datasets further enhancing our knowledge of offshore Zealandia.

These new datasets, building on CCP knowledge and the established scientific capability within CRIs, provided the foundation for new core-research programmes at GNS Science. These and subsequent projects/programmes have contributed significant advances in our understanding of New Zealand's sedimentary basins and tectonostratigraphic history.

Some selected advances include:

- Updated NZ geological timescale and advanced paleontological understandings;
    - Seismic revealing the Hikurangi subduction margin's structure and presence of extensive gas hydrate accumulations;
    - Recognition that coals can generate significant volumes of oil, aiding petroleum systems modelling fundamental to the discovery of new oil fields;
    - Detailed digital basin-scale paleogeographic maps;
    - Multi-disciplinary study of marine source rocks provided insights into significant early Paleogene environmental change;
    - Spatial and temporal interrogation of Taranaki Basin's geological fill effectively decoded the 'tape recording' of basin and tectonic history;
    - Research insights provided impetus for subsequent research programmes, voyages, and IODP expeditions.

The legacy of these extensive datasets will be underpinning knowledge that guides research in decades to come.

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The influence of off-fault deformation on the distribution of coseismic landslides from the 2016 Mw 7.8 Kaikōura earthquake

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7B: Active Tectonics, C2, November 25, 2020, 8:30 AM - 10:30 AM

Coseismic slope failures are observed in higher concentrations around surface rupturing faults, but the mechanisms by which the ruptures influence landslide susceptibility remain unresolved. Here, we investigate the role that coseismic off-fault deformation, which distributes slip off the primary fault plane through secondary faulting and other brittle deformation, played in landslide incidence during 2016 Kaikōura earthquake. We developed an updated method for measuring coseismic fault displacements and off-fault deformation zone widths using strike-perpendicular swaths on three-dimensional displacement fields derived from aerial photographs. Our method does not require field measurements and allows us to measure fault zone asymmetry. The initial results from 14 different surface rupturing faults show that the average off-fault deformation zone width is ~ 532 m for ruptures within the Marlborough Fault System as compared to ~ 611 m for ruptures within the North Canterbury Domain. Off-fault deformation is strikingly asymmetric about the Papatea fault indicating a wider zone of distributed deformation on the upthrown side of the fault. Using comparative landslide frequency ratios we demonstrate that off-fault deformation zone width better predicts coseismic landslide incidence than the distance to a surface fault rupture. While many mechanisms are likely involved in the ‘distance-to-fault’ metric, coseismic off-fault deformation may play a previously underappreciated role in the incidence of landslides near faults.

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Abstract of a Geo-technical Advisor: Two Years Volunteering in Vanuatu

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8A: Geo-Teaching & Practice, C1, November 25, 2020, 11:00 AM - 1:00 PM

In 2014, Volunteer Service Abroad in partnership with the Secretariat of the Pacific Community organised a technical advisor placement at the Government of the Republic of Vanuatu's Department of Water, Geology and Mines. In March 2015, Simon was finally briefed and cleared for travel however disaster struck – a category 5 cyclone tore through the country. VSA learned of an opportunity to help in the disaster response and so six weeks later Simon found himself touching down in Port Vila to witness the still raw devastation - over the next two years Simon tracked the healing of the people and the land. This talk will draw on the observations of an untrained development practitioner (Simon Bloomberg) and the in-country counterpart (Michel Leodoro) to provide insights and present on: the logistics of international volunteering; capacity bhilding and the counterpart-technical advisor-community relationship; some real scientific outcomes for the community in need; and the development opportunities for the future. Summarily, we will compare and contrast life in Vanuatu and New Zealand as a working geoscientist - and the outcomes our attempts to uplift the status of scientific knowledge in both communities.

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Effect of gas hydrate dissociation on seafloor stability

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The occurrence of gas hydrates in marine sediments is defined by the thermodynamic conditions of high-pressure und low temperatures. The response of gas hydrates to changing conditions, arising from geologic processes was analysed only by a few studies. These studies imply that the duration of re-adjustment, following a pressure decrease, or temperature increases may be in the order of thousands of years, during which gas hydrates could be present between the previous level of the base of gas hydrate stability (BGHS) and its level after adjustment. Besides ocean warming and sea-level fluctuations, rapid sedimentation can be another factor controlling the position of gas hydrates in marine sediments. Rapid sedimentation can lead to an upward migration of the BGHS resulting from an upwards shift of the isotherm. In addition to the significant time required for thermal re-equilibrium, other mechanisms like the endothermic nature of hydrate dissociation, slow salinity diffusion, and pressure dissipation may further delay this process. Emerging from that it is likely that following a sedimentation pulse, gas hydrates are still present below the new level of the BGHS for an extended period of time. To investigate the effects of rapid sedimentation and changing ocean conditions on the gas hydrate system, this study uses 1-D TOUGH+HYDRATE models, which are based on two locations along the Hikurangi Margin. At Site U1519 in the Tuaheni basin, the gas hydrate system had to adapt to rapid sediment deposition. The second area, Site U1517 is located in the Tuaheni Landslide Complex (TLC). We strive to reconstruct the development of the gas hydrate system beneath the TLC over geologic timescales and look at the possible contribution of gas hydrates to slope instability. First modelling results suggest that gas hydrates indeed stay stable and in place for thousands of years and are subject to hydrate recycling.

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MushPEC: Correcting post-entrapment processes affecting melt inclusions hosted in olivine antecrysts

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Following olivine-hosted melt inclusion (MI) entrapment, a series of processes can affect MI major element composition, e.g. post-entrapment crystallization (PEC) of the host mineral in the MI boundaries and diffusive exchange between the MI and its host. Classical correction schemes include PEC correction through addition of olivine to the melt until it reaches equilibrium with the host, and “Fe-loss” correction for Fe-Mg diffusive exchange as described by Danyushevsky et al. (2000). These corrections rely on the assumption that the original host composition is preserved and that hosts are not antecrystic.

We developed a novel MI correction scheme, applicable to more evolved (< Fo80) melt inclusions where the original host composition has not been preserved. The correction relies on fitting a set of MI compositions to modelled fractional crystallization (FC) liquid lines of decent. A Matlab® script called MushPEC iterates FC simulations using alphaMELTS2 (Asimow and Ghiorso 1998, Ghiorso and Sack 1995) starting from the most primitive MI composition of a set. A grid of initial conditions with variable P, H2O, fO2, olivine addition, and MgO/FeOt of the first MI are selected to simulate the possible magmatic conditions and the effects of PEC and Fe-Mg exchange on the first MI.

After the generation of the FC simulations, each MI is fitted to the FC paths by addition of olivine to the MI composition. The best fit for each MI is obtained by minimizing the compositional distance (Aitchison distance; Aitchison 1986) between the corrected MI and the FC path. The combination of the minimum Aitchison distances for the set of melt inclusion to each FC path is a measure of “goodness of fit” of each FC model to the corrected set of MI compositions. MushPEC allows constraints to be made on the intensive parameters in the mush, and its mineral phase assemblage.

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School of rocks: engaging students in earth science and geologic heritage

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Rural primary school students are relatively isolated from public libraries, museums, and research institutions, which may result in fewer opportunities to learn about and engage with science and technology compared to their urban counterparts. However, the proximity of remote schools to natural landscapes and geological features makes them ideally placed to engage students in earth science topics that are directly relevant to them. Students' existing connection with the land is the inspiration behind the "School of Rocks" Curious Minds project, an outreach programme that uses regional geology to deliver components of the science curriculum and demonstrate the relevance of scientific inquiry to students' own lives. In 2019 the School of Rocks programme delivered 20 fortnightly teaching sessions to each of the four classes (93 students total) at Duntroon School in North Otago. The principle learning outcome was for students to gain the skills they need to become responsible kaitiaki of the geologic heritage within the aspiring Waitaki Whitestone Geopark. Sessions consisted of hands-on experiences either in the field or at the Vanished World Centre in Duntroon, where we made use of the collections, dig room resources (limestone and fossil preparation tools), microscopes, and the outdoor rock garden. The frequent sessions allowed a comfortable learning environment to be established, where students could build on their ability to 1) make good observations; 2) understand different spatial scales; 3) gain perspective on deep time; and 4) apply the scientific method. On field trips, students explored local geosites and communicated their findings by designing information boards and GeoTrips. The School of Rocks programme demonstrates how existing connections to the land can be used to engage young people with earth science, while also involving them in the development of local Geopark initiatives.

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Reconstructing the dynamics of jets and pyroclastic currents of the 9 December 2019 Whakaari eruption

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6A: Volcanism, C1, November 24, 2020, 2:30 PM - 4:30 PM

Here we present an analysis of the volcanic phenomena that caused the death and injuries of the visitors to Whakaari on the 9 December 2019. We analyzed time-lapse imagery of four stationary webcams and infrasound data of the GeoNet monitoring network to reconstruct the characteristics of jets, ascending eruption plumes and jet-collapse derived pyroclastic currents for the only 206 seconds lasting event. We applied 3D photogrammetry to the webcam imagery to measure the spatiotemporal evolution of the jet, plume and pyroclastic current structures. This showed the occurrence of 13 individual explosion events, which produced sub-vertical jets, whose top parts transformed into buoyantly rising plumes and whose ascent heights increased from less than 80 m for the first jet to just over 600 m for jet 13, while vapour-rich material ascended to more than 3 km. The water- and mud-rich jets immediately collapsed vertically involving volumes of just above 20.000 cubic meters for the initial jet and about 58 million cubic meters of material for the final jet. While all collapsing jets fed pyroclastic currents, the main pyroclastic current was produced during the voluminous tenth jet collapse. Later collapses 11, 12 and 13 fed the propagating current. Flow front kinematics shows that the maximum speed of the pyroclastic current of c. 19 m/s was relatively low. However, momentum transfer of later collapses through internal waves sustained the flow in a slumping phase, characterized by significant ash load and dynamic pressure, for almost 700 m of runout, reaching the ferry landing site. Strong deceleration and dominance of viscous effects only occurred during spreading of the current over the open ocean and up to 1400 m from the vent. Finally, we identify the characteristic flow pulsing in infrasound data and apply a new turbulence model to reconstruct aspects of the internal flow structure.

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After the Big One: The Potential Impact of an Aftershock Sequence Following a Major Earthquake on the Hikurangi Subduction Interface

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4B: Hazards, C2, November 24, 2020, 8:30 AM - 10:30 AM

A major earthquake on the Hikurangi Subduction Zone Megathrust is one of New Zealand's largest geological hazards with the potential to cause severe ground shaking, tsunami, landslides and liquefaction across the North Island. Here we focus on what happens next for one particular scenario, the possible impact of a hypothetical aftershock sequence following a magnitude 8.9 earthquake along the interface. This work was done to help inform the scenario used in the design of the Hikurangi Response Plan. To help inform the scenario, we base the proposed aftershock sequence on the one that followed the Tohoku earthquake in 2011. We look specifically at the potential impacts of the largest aftershock in this hypothetical sequence, a magnitude 7.7 earthquake underneath the Wellington region that occurs half an hour after the mainshock. Not surprisingly, the effects of the aftershock of this size and location would significantly further worsen the impact of the earlier mainshock to this area. Given that this aftershock occurs mostly onshore and only just after the mainshock, it would not make the tsunami from the mainshock significantly worse. However, in the weeks, months and years after the mainshock there would be a significant increase in both the shaking and tsunami hazard faced by the whole of the east coast of the North Island from the aftershock sequence. Over the first year after the mainshock, we find that the east coast of the North Island has close to 100% probability of experiencing shaking above Modified Mercalli VI from an aftershock. Even a year after the mainshock there is still a significant (about 50%) probability of an offshore magnitude 7 of greater earthquake over the following year. The mainshock and its aftershock sequence would create a long lasting impact to New Zealand that would be felt for years.

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Late Holocene paleoearthquake rupture history of the Leader fault in North Canterbury prior to the 2016 Kaikōura earthquake.

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8B: Active Tectonics, C2, November 25, 2020, 11:00 AM - 1:00 PM

The Leader Fault is one of >20 faults that ruptured the ground surface in the north-eastern South Island of New Zealand during the Mw 7.8 2016 Kaikōura Earthquake. The Leader fault was not known to exist prior to the earthquake, although post-earthquake analysis of 1950s aerial photography has revealed many discontinuous active fault scarps. Six trenches were excavated across the Leader fault at four separate locations from 2018 to 2020. The trench walls primarily record near surface (< 4m depth) contractional deformation of Holocene stratigraphy. Early trenches (2018 & 2019) revealed subsurface displacements along faults that was substantially greater than the coseismic displacements of the Kaikōura earthquake, indicating prior rupture of these fault traces, however, insufficient dateable material was recovered to constrain the timing of prehistorical events. The best evidence for prehistoric earthquake(s) was observed in trenches excavated in 2020 across a pre-2016 scarp which accommodated 1.7 m vertical and 2.5 m left lateral coseismic displacement during the Kaikōura Earthquake. The trench revealed faulting, fissure fill and folding which formed during a surface-rupturing earthquake that pre-dated 2016. C_{14} dating of five in-situ carbon samples indicates that at least one earthquake occurred between 150 and 750 cal. yrs BP, with swamp accumulation on the downthrown side of the fault suggesting the existence of a scarp prior to this time interval. Data from a regional trenching campaign are consistent with latest Holocene earthquakes on the Humps, Leader and Hundalee faults and multi-fault rupture at this time cannot be discounted.

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Sub-ice shelf sedimentary record at Kamb Ice Stream Grounding Zone, Siple Coast, West Antarctica

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2C: Cryosphere, C3, November 23, 2020, 1:30 PM - 3:30 PM

The Kamb Ice Stream (KIS) is one of several that drain ice from the West Antarctic Ice Sheet (WAIS) and coalesce to form the Ross Ice Shelf. The behaviour of these ice streams on decadal to multi-millennial timescales is a key controller of WAIS mass balance, which in turn has implications for WAIS stability and global sea level.

In the 2019/20 Antarctic field season we collected short (~60 cm) sediment cores and sea floor imagery 6 km seaward of the modern KIS grounding line (82°47.05’ S, 155°15.76’ W), through a 584 m-long hot water drill hole through the ice shelf. The sediment cores are currently being analysed for radiocarbon, grain size, density (CT x-ray), siliceous microfossil content, elemental and mineral abundance, and sand-fraction petrography.

CT imagery and grain size analysis show that the upper ~60 cm of the seafloor is characterised by soft diamict with clasts of varying lithologies. Biogenic silica is present, mainly in the form of marine diatoms, ebridians, and silicoflagellates eroded from Neogene-age marine sediments. The relatively low bulk density of the matrix suggests that deposition probably occurred post-Last Glacial Maximum grounding. To address the regional paucity of dateable materials, ramped pyrolysis will be used to isolate carbon from different sources and determine a meaningful age. Clast petrology and fine-fraction XRF data are expected to provide provenance information and therefore erosional and transport history of the sediment. Initial results indicate that the lithological and physical properties of the core are similar to those of post-LGM sediments recovered at RISP Site J-9, approximately 170 km downstream of KIS-1, but lack the stratigraphic succession reported from post-LGM cores recovered from the Ross Sea.

This data will improve our understanding of the sedimentary characteristics of grounding-line proximal deposits, and contribute to our understanding of KIS behaviour following the LGM.

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Magma-ficent Earthquakes: Using historical records to inform baseline seismicity in the Auckland Volcanic Field

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7A: Volcanism, C1, November 25, 2020, 8:30 AM - 10:30 AM

The first expected signs of volcanic unrest in the dormant Auckland Volcanic Field (AVF) are small earthquakes (< ~M2), created as magma pushes its way through the crust. Correct early assessments of these earthquakes by the GeoNet monitoring project will be imperative for allowing a timely response by emergency planners, scientists, lifelines, and business and the public. Establishment of a 'seismic baseline' for Auckland may help us better understand what are considered 'normal' levels of seismicity so that unusual activity may be identified more quickly.
Our understanding of seismicity in Auckland is largely based on a post-1940 earthquake catalogue that routinely located earthquakes with magnitudes 4 and above and magnitudes 2.5 after 1992 when a volcano-specific network was established. Within this project, we aim to firstly expand the available earthquake catalogue for Auckland by collating and interpreting historical information regarding dates, depths, and magnitudes of earthquakes which have affected Auckland; secondly, combine this information with modern instrumental-period data sets; and finally, use statistical models to create a seismic baseline with which to compare during seismic activity. Information sources include historical records such as newspapers, felt reports and letters written during the early-instrumental period and seismic datasets from GNS Science/GeoNet from the modern instrumental period. Given the diverse information and data types available, researchers face unique challenges, including turning written accounts of 'fainting in the streets' from shaking into a reliable data point of earthquake magnitude, time, and location that is roughly comparable with modern instrumented assessments.
This work is being undertaken as part of the DEtermining VOlcanic Risk in Auckland (DEVORA) research programme to inform eruption scenarios and emergency planning, but we anticipate that the final approach and output could be used by those interested in incorporating historical earthquake records into seismic timelines, and for seismic hazard (re)assessments for Auckland.

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A 7300 year record of long- and short-term environmental changes (inc. a tsunami) in a backbarrier wetland, Moawhitu, Rangitoto ki te Tonga/d'Urville Island

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6C: Climate, C3, November 24, 2020, 2:30 PM - 4:30 PM

Three sedimentary sequences from Moawhitu wetland were examined using sedimentological, geochemical and microfossil (diatom) analyses, with the chronology established using radiocarbon and ^{210}Pb dating. Our study shows that a brackish lagoon started developing 7300 years ago after formation of the sand barrier, followed by periods of alternating wetland encroachment and open water, displaying spatial variations, until a peatland was established about 1300 cal. yr BP, and then partially drained in the early 1900s. A coarse layer containing gravel, sand and shells, with a sharp lower contact, in the northern area of the wetland, is attributed to an overwash about 2500-3000 yr BP, most probably a tsunami generated by the rupture of a local or regional fault. The high-resolution continuous record obtained with X-ray fluorescence (XRF) core scanning revealed a geochemical signature (Ca and S) for the overwash 600 m inland in the middle area of the wetland, while it was absent from the southern site 1.1 km from the shore. This suggests that, except at the northern end of Moawhitu, the sand dune acted as an effective barrier preventing any sediment from overtopping, with only a geochemical evidence marking the extent of seawater inundation. Diatom data in these intervals indicate that they were probably eroded from the sediment/underlying peat by the wave as it moved inland. No sedimentological or geochemical evidence could be found in the wetland for the 15th century tsunami that had destroyed almost an entire community in Moawhitu, as recounted in a pūrākau (Māori legend), although pebbles at the surface of the dune are likely to be linked to this event. Our study also shows that a high-resolution continuous XRF record can provide the evidence for short-term changes (catastrophic or not) that did not leave any clear sedimentological signature, thus providing a better insight of environmental changes.

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Delineating Mineral Resources By Integrating Biogeochemical And Geological Exploration Approaches Using Hyperspectral Remote Sensing

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7C: Minerals, C3, November 25, 2020, 8:30 AM - 10:30 AM

Biogeochemistry is an effective approach for orientation study in mineral exploration. It serves as a window to the sub-surface mineralogy utilizing the vegetation cover. This concept gave promising results under various geological settings; however, it has never been implemented within a remote sensing framework. The study aims to apply hyperspectral remote sensing to a localized gold-mineralization along the Hyde Macraes Shear Zone, a part of the Otago schist belt in South Island, New Zealand. Deep rooted plant species, such as Pinus radiata plantation, was targeted in this study along with soil and rock sampling, over a potential mineral-rich zone. The chemical composition of the soil and plant samples were analyzed using ICP-MS and were measured directly using a hand-held spectroradiometer. A 2m spatial resolution airborne hyperspectral data was also utilized, captured by the Aisa-FENIX sensor. This airborne hyperspectral data in association with the laboratory-based hyperspectral data and the elemental concentration data was analyzed to compute a relation between underlying gold-mineralization and biogeochemistry by identifying pathfinder elements to the gold-mineralization (e.g., As, Fe, Sb). Three commonly used multivariate regression models, including partial least squares (PLS), kernel partial least squares (kPLS) and random forest (RF) were tested. These approaches were selected to test the feasibility of detecting chemical anomalies and/or pathfinder elements to ore-bearing minerals in plant samples using lab- and airborne hyperspectral data. Despite the significant disparities between bark and needle data, the results showed that the lab spectra from bark samples had a better relationship with different elements (cross-validated R^2 >0.7). The prediction performance drops to R^2cv of 0.2-0.5 for the airborne data. This results from several factors including crown leaf spectra dominating majority of the pixels, uncertainties from image calibration, large spatial area. The research is to be extended to work on these disparities and formulate more robust models.

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10-years of earthquakes on and around the 2016 M7.8 Kaikōura earthquake

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6B: Transition Zone, C2, November 24, 2020, 2:30 PM - 4:30 PM

The 2016 M7.8 Kaikōura earthquake was a complex rupture involving multiple faults and crossing two separate tectonic domains. The Kaikōura earthquake was preceded in 2013 by the Cook Strait earthquake sequence that occurred at the northern extent of the Kaikōura rupture. We constructed a 10-year-long catalogue of earthquakes that occurred on the faults that ruptured in the Kaikōura earthquake to study how these faults responded to various large regional earthquakes, and how they healed following the Kaikōura rupture. We used a catalogue of 2,655 aftershocks with high-quality picks and locations as templates in a long-term matched-filter search from 2009-2019. We correlated these templates with continuous seismic data from 19 stations of New Zealand's GeoNet network. For all detected events we computed cross-correlation derived picks resulting in a catalogue of more than 30,000 well-recorded earthquakes. Of these, we were able to compute local magnitudes and precise relocations for 27,148 earthquakes. Our catalogue contains earthquakes ranging from ML 0.2 to ML 7.8. We computed time-varying magnitudes of completeness and b-values and observe systematic variations in b-value after both the Cook Strait sequence and the Kaikōura earthquake. By computing high-precision relative relocations we are able to accurately map earthquakes to the more than 20 faults that participated in the Kaikōura rupture. We demonstrate that the Kaikōura earthquake re-ruptured the same faults that the Cook Strait and Lake Grassmere earthquakes ruptured. We also show a continued lack of aftershocks on the Papatea Fault and the segment of the Kekerengu Fault that had the highest co-seismic slip, suggesting that these sections encountered near-total stress-drop, as well as a lack of seismicity on the underlying subduction interface. We observe additional crustal structures that did not have observable surface rupture, but which correspond to regions of peak modelled afterslip on the underlying subduction interface.

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Preliminary seismological results of the project ITOPNC, New Caledonia

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

12 broadband seismometers were deployed in 2018 and 2019 in southern New Caledonia for the project "Investigate Thickness Of Peridotite of New Caledonia" (ITOPNC). This project aims to construct a catalogue of earthquake locations/magnitudes, and to determine crustal structure/seismotectonics in southern New Caledonia and the broader region. Waveform data from 9 permanent broadband seismic stations are also being used in the analysis. Seven of them are from the regional New Caledonia network while the other two are from the global GEOSCOPE network. Current work focuses on earthquake locations and magnitudes, and velocity model construction. Preliminary results of M > 5 earthquake locations will be presented.

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Adjoint tomography of the Hikurangi subduction zone and New Zealand's North Island using an automated workflow

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6B: Transition Zone, C2, November 24, 2020, 2:30 PM - 4:30 PM

We have developed an automated, open-source workflow for full-waveform inversion using spectral-element and adjoint methods (Chow et al., 2020). As a study area we choose the eastern North Island of New Zealand, which encompasses the Hikurangi subduction zone. The chosen domain offers a unique opportunity for imaging material properties near an active subduction zone, due to the availability of well-recorded earthquakes in close proximity to the plate interface. We have performed realistic synthetic inversions using New Zealand source and receiver distributions to determine a set of parameters usable in real-data inversions. We have then undertaken an iterative inversion using 5,000 measurements from a subset of long-period (10–30 s) earthquake waveform data to resolve broad-scale velocity changes with respect to an initial ray-based 3D velocity model of New Zealand. Velocity changes are resolved at shallow crustal depths in tectonically active areas, such as the Taupō Volcanic Zone, regions of geodetically detected slow slip, and in the vicinity of the locked-to-creeping transition within the subduction zone. Improved fits between data and synthetic waveforms motivate an ongoing large-scale inversion using 200 earthquakes recorded on as many as 100 broadband stations. Initial iterations are used to fit long-period waveforms (15–30 s), while progressively shorter periods are introduced to a target period of 3 s, corresponding to features on the order of several km in size. We present ongoing efforts towards an accurate, high-resolution tomographic model of the North Island of New Zealand, which will be used to further understanding of enigmatic tectonic processes.

Phreatic eruptions from hyper-acidic wet volcanic systems: The role of hydrothermal sealing in the 27 April 2016 eruption from White Island, New Zealand

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6A: Volcanism, C1, November 24, 2020, 2:30 PM - 4:30 PM

An unheralded and dangerous ballistic-laden phreatic surge eruption occurred through a rapidly evaporating crater lake in the eruption crater complex of White Island on 27 April 2016. Whereas no juvenile material was recognized, a substantial proportion of the ballistics showed extensive hydrothermal alteration, exhibiting dissolution of primary mineral phases and varying amounts of sulphate mineral precipitation as both groundmass replacement and fracture-bound infillings. Evidence of repeated hydraulic fracturing and natroalunite re-sealing is common. Fluid inclusions in anhydrite have entrapment temperatures of between ca. 160 °C to 230 °C, and a number of these are clathrate bearing, with indicative gas pressures at time of entrapment ranging up to 40 bar.

Tough2 modelling provides valuable insights into physical processes operating beneath the lake. Magmatic vapours, simulated as mixtures of H_2O and CO_2, flow into the liquid saturated sub-lake environment along vertical zones of elevated permeability (fumarolic conduits). With free degassing of the conduit at the surface, this has the combined effect of both heating the conduit and adjacent aquifer environments, but it also convectively draws adjacent aquifer fluids towards the conduit along a positive thermal gradient. Uncoupled reactive transport modelling (X1t) of crater lake waters flowing along such gradients shows that they become supersaturated with respect to natroalunite at temperatures of ca. 200 °C, leading to precipitation of this phase and permeability reduction along fairly narrow lateral intervals. Higher in the system, uncoupled reactive transport modelling of magmatic vapour flowing into the liquid-saturated lake environment leads to elemental S and sulfate mineral precipitation. In time, both processes serve to encapsulate the upper conduit passage, effectively sealing it from the adjacent hydrothermal environment, and becoming loci for the collection of non-condensable gases (principally CO_2). Such gas columns are compressible and therefore potentially dangerous, with pressures regulated by the adjacent hydrostatically controlled aquifer fluids.

Geochemical signatures of epithermal Au-Ag deposits of the Hauraki Goldfield, Coromandel Volcanic Zone, New Zealand

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7C: Minerals, C3, November 25, 2020, 8:30 AM - 10:30 AM

The Hauraki Goldfield in the Coromandel Volcanic Zone, has ~50 epithermal Au-Ag quartz vein deposits that have produced >11 Moz Au and >50 Moz Ag from the 1860s to the present. Reconnaissance stream sediment geochemical surveys from the 1970s, with analyses typically of 4-10 elements, show primary dispersion of Ag, As, Au, Cu, Mo, Pb, Sb and Zn from erosion of the Au-Ag deposits. An orientation stream sediment survey in the Thames area with analyses of >50 elements additionally showed dispersion of Cd, Hg and Se, and that hydrothermal alteration was locally represented by elevated K and depleted Ca, Mg and Sr.

Prospect scale exploration has typically used rock chip geochemistry and/or soil geochemistry, and more recently limited biogeochemistry. These surveys identified local geochemical anomalies in As, Ag, Au, Ba, Cd, Cs, Cu, Hg, La, Mn, Mo, Pb, S, Sb, Se, Rb, Tl, W and Zn. The suite of anomalous elements varies between different deposits depending on their hydrothermal vein and alteration mineralogy, which in turn partly depends on the depth of erosion and exposure of deposits that have vertically zoned mineralogy, e.g. yielding shallow level As, Hg and Sb, versus deep level Cu, Mo, Pb, and Zn.

Hydrothermal alteration of country rocks principally involves the destruction of plagioclase releasing Ca and Na, and adding K with the formation of adularia and/or illite. Studies by previous workers show that these proximal processes may be identified in whole-rock analyses by a variety of hydrothermal alteration indices, e.g. K/Sr and Rb/Sr ratios, and plots of (2Ca + Na + K)/Al versus K/Al. Recently, K/Al molar ratios in pXRF analyses of drill core have been used in exploration to map secondary adularia and illite to vector to higher temperature alteration and potentially ore.

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Filling the gaps: progress toward an improved understanding of subduction earthquake hazard on the Hikurangi margin, New Zealand.

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7B: Active Tectonics, C2, November 25, 2020, 8:30 AM - 10:30 AM

Coastal tectonics studies by Kelvin Berryman and Yoko Ota have been foundational to our present understanding of subduction earthquake hazard along the Hikurangi subduction margin. Comprehensive field studies in the 1980's by Berryman, Ota and colleagues along the east coast from the Bay of Plenty to Kaikoura Peninsula set the scene for a broad understanding of the patterns of coastal uplift and subsidence. Through the 1990's, the developing scientific understanding of the Hikurangi subduction zone saw increasing recognition that coastal lagoons and terraces could hold the key to understanding the size and frequency of large subduction zone earthquakes, rather than more localised offshore upper plate fault earthquakes. Since the early 2000's, in ongoing collaboration with Dr Berryman, much of our research has focussed on detecting evidence for past large subduction earthquakes and transferring this information to scientists, stakeholders and the public.

Although significant progress has been made toward understanding the seismic and tsunami potential of the Hikurangi subduction margin, many knowledge gaps still remain. Future research directions on the Hikurangi margin fall into three broad categories of: (1) refining and densifying the coastal deformation and tsunami records; (2) integration of multiproxy ground shaking records; and (3) improving underpinning tectonic, sea-level change and chronological datasets. We will present a brief overview of our current state of knowledge about past subduction earthquakes and present a progress report on the steps toward filling our knowledge gaps about Hikurangi margin subduction earthquakes.

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Testing the influence of dyke wall properties on flow localisation during fissure eruptions

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Observations of historic fissure eruptions show that after several hours the eruptions typically localise to form cones or craters at one or more discrete points. While localisation is understood to occur when magma starts to solidify in parts of the fissure, creating blockages that focus magma along open pathways, the relative influence of wall rock properties on the location(s) of localisation, and the sensitivity of thermal feedbacks to changes in fissure geometry, have not been directly investigated.

Our scaled analogue volcanic fissure is designed to study these wall rock properties experimentally. The wall panels can be individually moved to vary the width and shape of the slot to create variable initial fissure-shape configurations, and they can also be moved during an experiment to simulate erosion of the wall rock or excavation due to cratering. The panels can also be cooled sufficiently to achieve similarity between the model and nature in different thermal regimes, for example different groundwater contents, or presence of an adjacent dyke.

Initial tests show that when the temperature of the wall is variable, the wax cools and solidifies more rapidly against cooler sections, focusing the molten wax into areas where the wall is warmer. Similarly, we predict that where the slot width is variable, solidifying wax will block the narrower sections more rapidly, causing molten wax to flow through wider sections, driving a thermal feedback loop. We expect partial blockages and initial focusing to cause localised differences in flow rate and flow patterns laterally along the fissure. Where the flow rate of fresh warm wax increases, thermal and mechanical erosion may cause melt back of the wax layer and a change in focusing. Experiments in which both the temperature and shape of the wall are varied will show which property induces strongest thermal feedbacks to dominate localisation.

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Constructing a model volcanic fissure for erupting a ton of wax

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4A: Volcanism, C1, November 24, 2020, 8:30 AM - 10:30 AM

Volcanic fissure eruptions commence with magma erupting through a crack that can be many kilometres long. As magma ascends through a fissure it solidifies in certain parts, driving thermal feedback that causes the flow to localise and erupt at discrete points. Understanding the controls on solidification and flow localisation will improve our ability to determine the location of eruptions, and focus hazard mitigation efforts to those areas.

We have prototyped and are building an analogue fissure to investigate the influence of wall rock temperature and crack shape on flow localisation and changes to the foci of eruptions along its length. Our scaled fissure will be 2 m long and 1.5 m tall, with a variable slot width of 5 – 20 mm. The analogue fluid is molten polyethylene glycol (PEG 600), which has a temperature-dependent viscosity and solidifies at ~ 22 °C. One wall of the fissure will be made of 70 aluminium panels that can be individually moved to modify the slot width and shape. The temperature of each of these panels can be controlled by passing warm or cold water through internal channels. Data will be acquired through visual observations and thermal sensors attached to each panel. We will also trace flow patterns and rates by particle image velocimetry (PIV) using fluorescent beads.

This will be the first lab-scale volcanic fissure with adjustable wall temperature and shape. The ability to control these properties for 70 discrete units of the wall creates a large number of possible experimental configurations to replicate, and support forecasting of, a wide range of natural scenarios. The results of this experimental program will directly contribute to hazard preparedness in densely populated and economically important urban areas that lie in close proximity to volcanic fissures, such as Auckland.

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Geochemical insights into shallow magmatic processes and transitioning eruption styles, Ambae, Vanuatu

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Ambae is the largest volcano in the Vanuatu Arc with eruptive activity having occurred at the summit and along the island's rift zone. Devil's Rock is a prominent outcrop on the SW coast. Eruptive deposits here record a transition from strombolian to phreatomagmatic eruptions and contain abundant olivine- and clinopyroxene-hosted glassy melt inclusions. Highly variable groundmass crystallinities provide excellent material to assess the underlying cause/s of eruptive behaviour, and are used to explain how magma is generated and modified beneath Ambae. This study aims to understand if the change in eruption style is a function of magmatic processes or properties (different composition, ascent rate, degassing history) or if it is driven purely by external factors (magma-water interaction/location).

Ambae melt compositions from the strombolian to phreatomagmatic phase record the same melt compositions and volatile contents, suggesting the same magma batch is involved throughout the eruption. Similarities in H_2O, CO_2 and S concentrations between Devil's Rock melt inclusions and groundmass glass with those erupted during the 2017–2018 summit eruptions highlight the possibility of a shared magmatic reservoir beneath Ambae.

Groundmass crystallization is negatively correlated with connected porosity in eruptive clasts from the transition zone, likely reflecting mixing of materials at the vent and inclusion of dense clasts from conduit margins. A direct comparison between crystallinities from the strombolian phase versus the phreatomagmatic phase suggests, a higher crystallinity, reflective of post-fragmentation crystallization of clasts. This is particularly evident in the proximal strombolian materials. Crystallization textures of melt inclusions are used in a similar fashion to groundmass to assess the relative timing of cooling. These trends mirror those of the groundmass and suggest longer cooling times for samples of the transitional materials. Overall these results suggest a dynamic system where changing crystallinities reflect different magmatic cooling histories for strombolian versus phreatomagmatic eruptive phases.

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Māui field history

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3C: Petroleum, C3, November 23, 2020, 4:00 PM - 5:30 PM

The Māui field celebrated 50 years since discovery and 40 years of production in 2019. The Māui field has a very rich story intertwined with the New Zealand energy landscape.

This presentation will cover the history of the field from discovery through to development and production and will highlight upcoming drilling activities.

The discovery of the field led to the birth of the Oil and Gas industry for New Zealand and numerous challenges required to be overcome to bring the field to production. Māui was one of the largest gas fields in the world at the time and a domestic gas market was effectively created as a result. In addition, offshore field development was at that stage, still novel on a world-wide basis and completely unknown in New Zealand.

Since discovery, eleven drilling campaigns have been undertaken, making use of the extensive monitoring and data acquisition carried out (including three seismic surveys: one 3D and two 4D's, the most recent in 2018). Active management has therefore allowed the field life to be extended far beyond that originally anticipated.OMV, the new owner of the field has brought in the Archer rig to the Māui A platform and will start an infill campaign shortly.

Whilst today's challenges are certainly different than on day one, they are still met with the same passion, persistence, and creativity as on day 1 by all those involved in the development and operations of the field to ensure that Māui continues to feature on the New Zealand energy supply map.

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Gas-particle transport and sedimentation of pyroclastic currents across topographic obstacles

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4A: Volcanism, C1, November 24, 2020, 8:30 AM - 10:30 AM

Pyroclastic currents are dangerous multiphase flows from volcanoes. The recent eruptions from Te Maari in 2012 and Whakaari in 2019 demonstrated their enormous hazard potential at New Zealand volcanoes despite low eruption magnitudes. While the hostile nature of PC presents enormous challenges to direct studies of their flow behavior, sedimentological analyses of their deposits can help reconstructing the conditions of the parental flow after an eruption. However, this needs a quantitative understanding of the relationships between flow-internal characteristics and resulting sedimentary characteristics.
Here we present the results of large-scale PC experiments where we synthesize the scaled conditions of hot PCs over natural landscape models. We characterize the flow velocity, turbulence, density, grain-size distribution, temperature and dynamic pressure of the evolving vertically stratified gravity current, while capturing the erosion and deposition events at the same time. This allows the reconstruction of the spatiotemporal deposition evolution of PC deposits over the complete flow runout of 35 m. In a systematic series of experiments, we introduced three differently sized and geometrically self-similar hill obstacles into the flow path whose shape is an average of topographic obstacles around Te Maari, Ontake and Merapi. Topographic obstacles have variable effects on the PC deposition: for obstacles with heights half of the lower boundary layer, asymmetric deposition with up- and downstream accreting bedforms occur before and immediately behind the obstacle; for obstacles slightly larger than the lower boundary layer height partial flow blocking produces strong deposition and upstream migrating bedforms before the obstacle, low-shear tractional bedforms immediately behind the obstacle in a low-pressure zone and downstream-migrating bedforms after that; for obstacles more than half of the current thickness, significant flow blocking leads to an interaction of upstream and downstream migrating bedforms before the obstacle, while behind the obstacle the strongly diluted current deposits by low tractional shear.

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The basis for chromite-melt diffusion chronometry in an oxybaro-geospeedometric context

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

When primitive mantle-derived magmas enter the crust and cool, the crystallization of ferro-magnesian silicate minerals such as olivine drive melt compositions into a relatively oxidized state, as Fe3+ is incompatible in such silicates. If chromite crystallizes prior to or concomitantly with olivine in the primitive melt system and if the melt remains siliceous enough to ensure chromite stability during magmatic differentiation, then the composition of chromite in equilibrium with residual melts will become more ferric as melt Fe3+/ΣFe increases.

Thus, early crystallized chromite grains entrained in a differentiated melt will be in chemical disequilibrium with respect to Fe3+ concentration. Diffusive equilibration of Fe3+ progresses via the exchange of trivalent Cr and/or Al in chromite with Fe3+ in the melt.

Therefore, one explanation for chromite crystal zonation with respect to Fe, Al, and Cr is that the diffusion of Fe3+ into chromite failed to completely re-equilibrate chromite with its host magma prior to eruption. Such features should be contextualized by examination of Fe2+-Mg equilibria in order to assess for mineral (both oxide and silicate)-melt equilibrium of this subcomposition. In the case where microlitic silicates like pyroxene are in chemical equilibrium (with respect to Fe2+-Mg) with both zoned chromite and melt phases, then the silicate (i) crystallized after the chromite to alter melt Fe3+/ΣFe, (ii) the zonation of the chromite grain likely reflects Fe3+ heterogeneity and (iii) the profiles of Fe, Al, and Cr in the zoned chromite may be interpreted in a diffusion-chronometric context.

Further work on the diffusivities of these elements in spinel-structured oxides is required to better constrain timescale information regarding changes in melt oxidation state and temperature during magma ascent and/or eruption based on chromite zonation. We will provide natural examples of these processes.

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Earthquake risk treatment – understanding trade-offs and building buy-in

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2B: Hazards Symposium, C2, November 23, 2020, 1:30 PM – 3:30 PM

Awareness and perception of 'risk' is about proximity – meaning the timing or location of a potential loss or gain. This may involve events imminent or distant, but uncertainty nudges people toward assessments based on recalled experience or imagined outcomes that seem reasonable – i.e. not too remote. Because of the uncertainties around the likelihood and timing of rarer events, survival actions typically are prioritised over those which might reduce or avoid risk. This is because the benefits of the former are attributable and instantaneous, whereas the latter tend to be more widely distributed and accrue incrementally.

Hazard events may be locally devastating, but wider perception and awareness of their significance depends on the population affected and the severity of disruption including the duration and complexity of recovery. This is common to all hazards, and particularly insidious for slow-onset events such as prolonged drought, sea-level rise, or land subsidence. The frequency and duration of disruption may influence how widely memories are retained but traditional practices – land use, expectations of amenity, entitlement, and problem-solving are, by definition, quite resilient. This explains why 'loss experiences' tend to be ephemeral, especially beyond the communities affected.

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The geological history and hazards of a long-lived stratovolcano, Mt. Taranaki, New Zealand

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6A: Volcanism, C1, November 24, 2020, 2:30 PM - 4:30 PM

Mt. Taranaki in the western North Island erupts magmas with subduction-related signatures. These don't appear to relate to the present Hikurangi subduction system, because the slab descends sub-vertically east of the volcano. Instead, magmas may be generated by fluxing of inflowing mantle material from the northwest that was already metasomatized in the Miocene. Over the last 200 ka, Mt. Taranaki eruptives have become more potassic. Basaltic melts originate in the upper mantle lithosphere and interact with amphibolite at the base of the crust. Evolved hydrous magmas rise and pause in mid-upper crustal reservoirs. At least 228 tephras erupted over the last 32 kyr, displaying a 1000-1500 yr-periodic cycle over which eruption frequencies vary five-fold. Compositional and tephra size relationships indicate a magmatic supply control, possibly coupled with tectonic/stress regime. The edifice has collapsed and re-grown 16 collapse times over the last 200 ka, with three events generating >7.5 km3 debris avalanche deposits. Collapses appear to be tectonic/magmatic triggered, associated with magma intrusion along N-S trending structures. The largest eruptions produced Plinian columns 25-27 km high, emplacing 0.1 to 0.6 km3 pumice fall deposits throughout the North Island. Smaller explosive eruptions or effusive dome-forming and collapse episodes are more frequent. The eruptions are often long, complex sequences of multiple phases, but contain recognisable patterns. Most episodes produce pyroclastic density currents, with block-and-ash flows from dome-collapses reaching 13 km from the vent, and pumice-rich pyroclastic density currents of >500oC travelling up to 23 km from source. The last eruption in AD1780 was similar to the previous ~1000 years of mainly dome-forming events. The present annual probability of eruption of any type is 1-1.3%. The relatively long period since the last event makes it increasingly likely that the next eruption will involve newly recharged magma.

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Impacts of seamount subduction on frontal accretionary and upper-plate deformation along the Northern Hikurangi subduction margin, New Zealand

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Subducting seamounts can have a profound impact on the structure and morphology of tectonic wedges. The passage of subducting seamounts is commonly associated with deformation corridors, the formation of structural re-entrants in the wedge front, and upper-plate extensional faults which overprint contractional structures and associated seabed morphology. Using high resolution multibeam swath bathymetry and regional seismic reflection profiles tied to IODP Expeditions 372 and 375 drilling data, we examine the role of past and present seamount subduction on outer wedge morphostructure along the northern Hikurangi subduction margin.

Comprised of a narrow (~40 km) and steep (>10˚) outer wedge, the northern Hikurangi Margin is significantly deformed and varied compared to the gently tapered (~4˚), wide (~120 km) accretionary wedge observed further south. The northern margin can be split into two sections that reflect repeated seamount subduction of varying temporal and spatial scales during the last ~2 Ma. Furthest north, the Ruatoria re-entrant represents an end-member of seamount subduction through mass wedge failure occurring ~2.0–0.16 Ma. Active NW-SE extensional faults along the southern edge of the re-entrant, however, indicate contemporaneous upper-plate gravitational collapse is deforming the outer wedge. South of the re-entrant, the continental slope varies from slope-concave to convex at ~38.5˚ S; likely associated with a subducting seamount. A pervasive upper-plate extensional fabric associated with shallow wedge failure is overprinted by a tightly folded subduction deformation frontal thrust that shows limited frontal accretion of recycled upper-plate material and trough sediments. In both cases convergence rate and sediment thickness on the incoming plate are comparable, with differences in bathymetry and overriding plate structure mainly reflecting the location, timing, and inferred geometry of subducting seamounts. Outer-wedge convexity and normal faulting becomes more subdued as seamount subduction advances; however, extensional fabrics can persist in the outer wedge long after a seamount is subducted.

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Expanding the Footprint of Orogenic Gold: Trace Elements in Sulphides Showing Potential

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7C: Minerals, C3, November 25, 2020, 8:30 AM - 10:30 AM

The refractory gold-dominated (with minor free gold in quartz veins) deposit at Macraes, Otago, NZ is hosted within the Hyde-Macraes Shear Zone (HMSZ) in the northeastern margin of the Otago Schist. Gold was sourced from seafloor sediments containing diagenetic pyrite framboids and was released during recrystallisation of pyrite to pyrrhotite during greenschist metamorphism. The gold was then mobilised in metamorphic fluids that were produced by dehydration reactions at the transition from greenschist to amphibolite facies. These fluids were subsequently focussed along permeable structures formed by competency contrasts enhanced by silicification and graphitisation. The gold was the deposited and incorporated into disseminated sulphides and minor free gold in quartz veins.

This updated work uses optical petrography, continuous scanning x-ray fluorescence (ITRAX) and laser ablation-inductively coupled plasma-mass spectroscopy (LA-ICP-MS) on sulphides in a known ore zone. These methodologies are used to determine how trace element concentrations vary with distance and how they are interrelated/distributed in individual sulphides.

With these data, we seek to guide exploration through increased resolution of the ore zone via distinguishing mineralised hydrothermal sulphides from their relatively barren metamorphic counterparts.

Our latest results have corroborated earlier findings that sulphide-gold (within the sulphide structure) has a strong positive correlation with arsenic in pyrite and weaker correlations with copper, zinc, and silver. Micro-nugget gold (discrete particulate gold within sulphides), appears to be more abundant in arsenic-poor regions of sulphides, suggesting that substitution of arsenic for sulphur in pyrite may promote incorporation of sulphide gold and prevent micro-nuggets from forming in high arsenic regions. When sulphide gold, arsenic, copper and zinc concentrations are plotted against depth, there is a systematic increase in concentration from distal to proximal sulphides around the ore zone. Under the correct working conditions, the ITRAX scanner shows good potential for use as a rapid and non-destructive assaying tool.

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Three Centuries of Southwest Pacific Gyre Biogeochemistry Reconstructed from a New Zealand Black Coral

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Over the 20th century, increasing westerly wind stress has driven an intensification of the planet's ocean gyres. Around New Zealand, acceleration of the South Pacific Gyre (SPG) manifests as stronger subtropical gyre currents, transporting warm, macronutrient-poor waters poleward and likely impacting net primary productivity. Are modern changes anomalous? The oceans naturally vary on timescales of centuries so assessing the impact of 20th century circulation changes on marine biogeochemistry requires records that predate the instrumental era. Here we present a reconstruction of marine biogeochemistry in eastern New Zealand waters spanning 1684 – 2009 C.E. from a deep-sea black coral collected from the west Chatham Rise. Black corals can live for millennia, can be precisely dated by U-Th disequilibrium, and incorporate the $\delta^{13}C$ and $\delta^{15}N$ signatures of sinking particulate organic matter into their skeletons. This makes them ideal high-resolution archives of marine biogeochemical information.

Our Suess-corrected $\delta^{13}C$ and $\delta^{15}N$ record shows coupled multidecadal $\delta^{13}C$ and $\delta^{15}N$ variability and significant negative trends from 1900 C.E. to present. These trends suggest an increase in 20th century bioavailable nitrogen and net primary productivity (NPP), corresponding to gyre intensification seen over the 20th century. However, NPP along eastern New Zealand is supported by nitrate supplied by sub-Antarctic waters and upwelling. Both of these would be suppressed by southward penetration of subtropical waters, which would displace sub-Antarctic waters and inhibit upwelling through increased stratification of the sea surface. Therefore, while instrumental studies suggest the gyre has transported more subtropical waters to New Zealand, our data suggests these may not have penetrated as far as the southeast Chatham Rise.

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Seafloor pockmarks of the Chatham Rise, Canterbury Slope and Bounty Trough -distribution, structure and potential formation mechanisms

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3A: Unravelling the Seascape, C1, November 23, 2020, 4:00 PM - 5:30 PM

An area, > 50,000 km^2, of the Chatham Rise, Canterbury Slope and Bounty Trough, is rich in pockmarks ranging in diameter from 100 m -12 km and 2-100 m deep. Shallow pockmarks, between 450 and 750 m water depth, were originally interpreted to have formed by methane escape from disassociated methane hydrate deposits. However, geochemistry results from survey SO226 on R/V Sonne, found no evidence for vertical CH_4 flux within pockmarks sampled. The match between the distribution of pockmarks and the interpreted area of the subducted Hikurangi Plateau led to the interpretation that the pockmarks were formed by escaping CO_2 released from disassociated limestone subducted atop the flat-subducted Hikurangi Plateau.

High resolution, sub-bottom, seismic profiler images reveal a sedimentary pattern of high amplitude reflectors and intervening lower amplitude units. This pattern is interpreted to visualise the alternating sedimentary regime of increased mineral content at low-stand sea-level and carbonate deposits at high-stand sea-level. Using this interpretation, it is apparent that the 100-200 m diameter pockmarks formed in the 450-750 m water depth range, formed principally on glacial termination horizons.

The mechanisms of CO_2 migration and release at glacial terminations are still being evaluated. The widespread presence of Paleocene-Eocene polygonal faulting throughout the Bounty Trough and up onto the southern flank of the Chatham Rise, is likely caused by dewatering from an Opal-A to Opal-CT transition or sediment compression dewatering. The former mechanism has been proposed as another origin of pockmark formation.

Pockmark and sub-seafloor features will be presented along with a discussion of possible CO_2 migration and seafloor venting mechanisms responsible for the range of pockmarks observed.

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Using historical aerial photos to estimate 2-D and 3-D displacements from the 1987 Edgecumbe earthquake, New Zealand

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Photogrammetry and structure-from-motion (SFM) techniques provide additional tools for measuring 2D and 3D coseismic displacements, particularly where and when other high-resolution topographic data are unavailable. We used historical aerial photosets in the northern Taupō Volcanic Zone of New Zealand to generate the first coseismic displacement fields of the complex surface rupture of the 1987 M6.4 Edgecumbe earthquake. This moderate-magnitude earthquake tests the limits the technique, which is usually applied to larger magnitude earthquakes (M7+) with multi-meter slip, because the modest displacements (~1-2 m) in low-relief terrain approach the limits of the resulting elevation products and differencing methods, respectively. We generated horizontal and vertical displacement from SFM-derived digital surface models, point clouds using an iterative closest point algorithm, and with orthophotos using sub-pixel correlation. Horizontal and vertical displacement values are compared to measurements from modern lidar and post-earthquake field and levelling surveys to evaluate the successes and limitations of this technique. We demonstrate that the aerial photos in this region are sufficient for generating displacement fields but the success of the final SFM-based topographic products is highly dependent on the resolution of the images, camera and lens parameters, accurate ground control, and the size of the target displacement, and therefore may not be suited for all locations. Here, aerial images successfully allow generation of both pre- and post-earthquake topography useful for understanding earthquake behaviour over historical time periods. In particular, our new data on the 1987 Edgecumbe earthquake provide a more complete understanding of earthquake behaviour by revealing off-fault deformation and slip on additional faults not recognized during event response, and expand our catalogue of high-resolution coseismic displacements to include a shallow, moderate-magnitude earthquake.

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Real-time Eruption Forecasting and Early Warning at Whakaari

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6A: Volcanism, C1, November 24, 2020, 2:30 PM - 4:30 PM

Sudden steam-driven eruptions strike without warning and are a leading cause of death for tourists visiting volcanoes. Recent fatalities following the 2019 Whakaari eruption in New Zealand suggest there is a need for forecasts that can update on short time scales: hours to days. We used time-series feature engineering to identify eruption precursors in real-time seismic data streamed from Whakaari, New Zealand. We identified four-hour energy bursts that occur hours to days before most eruptions as particularly significant signals. We suggest these indicate charging of the vent hydrothermal system by hot magmatic fluids. Other important signals include 40-min RSAM oscillations that could indicate boiling instabilities in the hydrothermal system. We trained a model to recognise these precursors in real-time data and developed a system for short-term alerts during periods of elevated eruption likelihood. Under cross-validation (pseudoprospective) testing and an optimized alert threshold, this forecasting system could provide advanced warning of an unseen eruption in four out of five instances, including sixteen hours warning for the 2019 eruption. On the other hand, an eruption is 2016 was not caught, likely because a lack of magmatic contribution meant its precursors were unrecognized. The average alert duration for this system was five days and there was a 1 in 12 likelihood for an eruption to occur during an alert. Total alert duration was 8.5% of the study period: about one month each year on average. We suggest this level of accuracy and specificity represents an improvement over the current Volcano Alert Level system. However, future eruptions exhibiting different eruption precursors are unlikely to be detected.

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Tectonic geomorphology and paleoseismology of the Torlesse fault, mid-Canterbury, New Zealand.

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8B: Active Tectonics, C2, November 25, 2020, 11:00 AM - 1:00 PM

The Porters Pass – Amberley Fault Zone located in mid-Canterbury, South Island has been identified as one of the main sources of regional seismic hazard to Christchurch, but we have virtually no information on its active >20 km-long backthrust, the Torlesse fault. We used field mapping, surveying (GPS and SfM photogrammetry), trenching, and luminescence and radiocarbon dating to characterise the Torlesse fault. From survey results, we measured horizontal and vertical displacements ranging from 4 to 15 m and 0.5 to 5 m, respectively, across offset terraces and stream channels assumed to be younger than the Last Glacial Maximum. There is evidence for three surface rupturing events from three different trenches, including one recent event in between 283 and 130 years before present. Time-integrated slip rates on strike-slip faults of the survey area vary from c. 0.3 to 0.7 mm/yr, but better age control is required to the offset features to confirm these numbers. Net slips from c. 3.3 to 5.3 m and slip rates varying from c. 0.22 to 0.29 mm/yr were estimated on two dip-slip faults at the Porter River terrace, previously used to estimate the slip rate of the entire fault but here identified as flexural slip faults. From the ages of events obtained from the trenches, an estimated recurrence interval for the fault is c. 5,000 years. Newly modelled ages from the Porters Pass fault and the ages presented in the study demonstrate that the Torlesse fault is a distinct seismic source, raising questions about how ruptures branch at depth to the surface beneath the Torlesse Range.

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Low-Energy, Erosional Boulder Beaches, Eastern Tasman Bay, New Zealand

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2A: Unravelling the Seascape, C1, November 23, 2020, 1:30 PM - 3:30 PM

Throughout the world, boulder beaches are commonly associated with high-energy wave environments. However, in eastern Tasman Bay several geomorphic features such as wave-cut platforms, boulder beaches and spits are situated in relatively low-energy wave environments, which have persisted throughout the Holocene.

We present side-scan sonar, bathymetry, topography, and clast distributions for two boulder-cobble beaches; one in Greville Harbour and the other on Motuanauru Island. Results indicate that these coarse gravel features extend seaward by several hundred meters and to depths greater than 20m. Clast counts indicate that the beaches are formed of poorly-moderately sorted boulders, cobles and pebbles with some boulders >1m in diameter. Wave simulations representing cyclone conditions in Tasman Bay show longshore movement of cobble-sized clasts on either the beach face or intertidal areas is not possible.

A model concerning the origin of these beaches and platforms must account for the 1) local source, 2) rounded shape, and 3) poor sorting of the gravels. The boulder beaches appear to be in situ features derived from resistant bedrock, which lies below and seaward of the gravels. The overall shape and position of the beaches are mostly a product of geologic structure with only minor modification by coastal processes.

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Creation and destruction of Holocene marine terraces at Mahia Peninsula

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8B: Active Tectonics, C2, November 25, 2020, 11:00 AM - 1:00 PM

Uplifted Holocene marine terraces occur globally along tectonically active rock coasts and record critical information about paleoearthquake timing and magnitude. A spectacular global example of Holocene terraces occurs along Mahia Peninsula, Hawke Bay. Berryman (1993) first described these terraces and determined their height and age. Berryman et al. (2018) then described a detailed facies assessment of terrace coverbeds and provided new radiocarbon ages to constrain earthquake ages. In this presentation we describe a new programme of research following this pioneering work which seeks new insights into marine terrace formation at Mahia Peninsula. Our research programme combines mapping from historical photographs, field measurements of process dynamics, analyses of in-situ produced cosmogenic nuclides, and numerical modelling of coastal evolution in the presence of episodic uplift. Our focus involves investigating both the generation and destruction phases of terrace evolution. In this presentation we will present results documenting historically observed destruction of the youngest terrace at Kahutara Point (Table Cape), Mahia, and forecast the period over which this terrace could be removed from the landscape. Results will then be presented from a numerical model set up to explore the development of the Mahia terrace sequence. Model results are generally consistent with the field data and interpretation described by Berryman et al. However, in exploring some inconsistencies we uncovered how both episodic (tectonic) and gradual (climatic) changes in relative sea level modulate inter-seismic shore platform development, and recognised flow-on implications for terrace preservation potential. Model results show that the magnitude of sea level change relative to the tidal range is crucial, because even subtle differences in relative sea level history can create significant differences in the intertidal erosion process regime that is responsible for terrace creation and destruction. These results have important ramifications for interpretation of paleoseismic records from uplifted marine terraces.

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Insights from benthic foraminifera on Lyttelton Harbour/Whakaraupo sedimentation and anthropogenic impacts

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4C: Sediments, C3, November 24, 2020, 8:30 AM - 10:30 AM

Benthic foraminifera are shelled protists that are common in marine sediments and are an ideal tool for monitoring and characterizing the health of marine ecosystems. Lyttelton Harbour/ Whakaraupo hosts the Port of Lyttelton and has undergone frequent dredging, yet the anthropogenic impacts of these activities on the harbour remain poorly understood. This study characterized the benthic foraminifera in Whakaraupo to investigate sediment conditions and organic pollution impacts on preservation of forams in harbour sediments and to determine living depth of forams in the harbour. Three 20 cm push cores were collected in Charteris Bay, subsampled, and stained to reveal live and dead forams at the time of collection. Forams were picked and characterized by species, density per gram of sediment, size, live or dead status, and corrosion (for calcareous taxa). Results are compared to the neighbouring Avon-Heathcote/Ihutai Estuary, which has higher pollutant levels from nearby Christchurch wastewater treatment plants. Charteris Bay cores were dominated by Ammonia aoteana and exhibited low diversity, typical of marginal marine environments. Foram density decreased up the cores, which could be indicative of increasing sedimentation rates in Lyttelton Harbour/Whakaraupo due to dredging and sediment redistribution from the Port of Lyttelton. Foram densities in Charteris Bay were high compared to the Avon-Heathcote/Ihutai Estuary, suggesting heathier sediment conditions in Lyttelton Harbour/Whakaraupo. Corrosion of calcareous taxa increased with depth, likely due to increasing decomposition and pore-water acidity with depth. Living depth did not deepen moving inshore due to less frequent inundation as had been hypothesized. Future work will sample Lyttleton Harbour/Whakaraupo foraminifera and geochemistry over greater spatial and temporal gradients to establish a baseline for future monitoring efforts and map sedimentation rates in the harbour.

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Deciphering magma storage and ascent processes beneath Taranaki volcano, New Zealand, from the complexity of amphibole breakdown textures

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Lava flows that constitute the current edifice of Taranaki volcano, New Zealand, contain a complex crystal cargo including plagioclase, pyroxene, amphibole, oxides and rarely olivine. Amphibole textures and mineral chemistry indicate that crystals are pargasitic antecrysts entrained at various depths by ascending magmas. The crystals record a complex growth history within a range of temperature and pressure conditions (c. 950-1000°C and c. 9 - 4 kbar). Most amphiboles show the development of distinct reaction rims where the mineral is in contact with the ambient melt. Texturally, the rims are identified as detached, symplectic, granular or coarse. True rim thicknesses vary little (±20%, 1σ, on average) within individual thin sections but show a large variation between samples from different lava flows, from < 5 µm to > 50 µm. Reaction rim formation on Taranaki amphiboles is attributed to degassing during magma ascent. Associated with the formation of rims, the amphiboles also show two types of volumetric decomposition, one indicative of the role of local kinetic controls on amphibole breakdown during decompression-induced degassing, the other indicative of heating-induced breakdown of the amphibole triggered by their uptake into hot magmas prior to the onset of eruption. The combined evidence indicates that despite the complex and variable growth history of the remobilized crystal cargo, such antecrysts can be used to constrain pre- and syn-eruptive processes and their rates. At Taranaki volcano, magma ascent times calculated from reaction rim thicknesses are estimated to be typically shorter than 10 days.

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Stratigraphy and Preliminary Results from the May 2019 drilling campaign of the 3.48 Ga Dresser Formation, Pilbara, Western Australia.

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4C: Sediments, C3, November 24, 2020, 8:30 AM - 10:30 AM

Increasingly, research has favoured the origin of life on Earth in terrestrial hot-springs (Damer & Deamer, 2014; Mulkidjanian et al., 2012; Van Kranendonk, Deamer, & Djokic, 2017). Recently, siliceous hydrothermal deposits interpreted as hot spring related (sinter), were identified in the 3.48 Dresser Formation, Pilbara Craton, Western Australia (Djokic, et al., 2017), which extended the first fossil evidence of life on land by ~130 million years and of terrestrial hot springs by ~3 billion years.

The Dresser Formation represents an ancient, dynamic, hydrothermal-volcanic caldera setting (Van Kranendonk et al., 2008; Djokic et al., 2017). Sinter, particularly geyserite, has been found in above the shallowest parts of extensive barite-chert hydrothermal feeder veins (Djokic et al., 2017). Other microbial textures include pyritic stromatolites and dendritic fabrics (Djokic et al. 2020). However, identifying biosignatures in Archean rocks is difficult due to billions of years of erosion, deformation, and metamorphic alteration. The hot sinter deposits discovered in the Dresser Formation were previously studied from mapped surface outcrops that are weathered to 10’s of metres depth (Djokic et al., 2017). Therefore, in May 2019, fresh Dresser deposits were drilled to aid in a better understanding of this ancient hydrothermal system, and the paleoenvironmental context of microbially influenced hot spring deposits.

Here we present preliminary stratigraphy from 3 unweathered cores of 5-30 m thickness, drilled from ~70 m beneath the land surface. In particular, we discuss macro- to micro-scale textural features, to provide context for the at least 10 sedimentary lithologies identified within the cores. We provide comparison of potential Dresser hot spring deposits with modern and fossilised hydrothermal analogues in other areas of the world (e.g. New Zealand's Taupo Volcanic Zone, and Coromandel Miocene sinter). Results are compared to recent Origin of Life studies and hot spring deposits discovered on Mars by NASA’s Sprint rover.

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Using pollen to investigate sediment sources in a lacustrine environment: Implications for Paleoclimate records

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The proxies embedded within both lakes and bog sediments provide information on both climatic and vegetation changes. When developing paleoclimate records based on pollen, peat bogs are favoured due to passive modes of accumulation and simple proxy source models. However, slow accumulation rates result in low resolutions and poor recording of decadal to centennial scale environmental changes. Lacustrine systems offer higher resolution records, robust chronologies, and a multitude of supporting proxies. However, modes of accumulation are complex, and the role fluvial processes and lacustrine dynamics play in shaping paleoclimate records is poorly understood. Unpacking these processes is complex, thus lacustrine records are underutilised in pollen-based paleoclimate research. Pollen taphonomy can indicate sediment sources and pre/post depositional processing. Therefore, not only can pollen be used to investigate climate, the role of catchment processes in shaping the final record can be unpacked. Parallel pollen-based paleoclimate reconstructions have been developed from an adjacent lake-bog complex at South Mavora. With the bog record acting as a control, pollen taphonomy has been used to investigate inputs into the lacustrine environment. A conceptual pollen input model for South Mavora lake has been constructed alongside a 10,000 year, high resolution multi-proxy, dual record environmental reconstruction.

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Distribution and abundance of foraminifera in Lyttelton Harbour/Whakaraupō.

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Historical fluctuations in climate are often deduced from fossil assemblages, with modern distributions used to infer past conditions based on species occurrences and assemblages. My research is focused on benthic foraminiferal assemblages in Lyttelton Harbour/Whakaraupō, analysing the distribution to infer local ecological preferences of each species. Mapping foram distribution in Lyttelton Harbour/Whakaraupō against sediment types and tidal elevation will inform fossil assemblage usage for tracking of sea level change and interpreting marginal marine environments. Percentages and abundances of foraminiferal species measured in Lyttelton Harbour/Whakaraupō are mapped against grain size, organic carbon content and relative sea level for each location. Additionally, little is currently known about the life cycles of intertidal forams. While it is possible local foraminifera will bloom on a seasonal basis it is known from overseas studies that blooms may extend over several years. In this study the life cycles of *Ammonia aoteana* and *Trochamminita inflata* will be determined through repeated sampling at fixed sites from mid 2020-2022 to help answer seasonality and life cycle length questions. Combined data on foraminiferal abundance, diversity, life span and life cycle, and ecological variability in modern foraminifera in South Island species will therefore better aid local paleoenvironmental reconstructions. This can improve on our understanding of the effects of past climate and environment shifts and local variations in sediments and sea levels.

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Violent Taupō eruption triggered a megathrust earthquake in 6th century CE

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5A: Volcanism, C1, November 24, 2020, 11:00 AM - 1:00 PM

Understanding the relationships between volcanoes and earthquakes at convergent plate boundaries depends on robust tephrochronology. The Taupō First Millennium eruption, long considered securely dated by wiggle match at 232 ± 5 CE, underpins New Zealand's Late Holocene, radiocarbon-rich earthquake chronologies on the Hikurangi subduction margin (HSM). We re-evaluated the stratigraphic context of Taupō tephra in marine/marginal marine radiocarbon chronologies from the northern HSM, disregarding the wiggle match age. Beach records from Table Cape at Mahia, Pakarae River mouth, and Puatai Beach yielded an eruption date of 549 ± 64 CE. Radiocarbon ages on foraminifera from offshore turbidite cores enclosing the tephra yielded a date of 545 ± 136 CE, from tests that pre-date the turbidites. Both dates exclude the wiggle match date at 95% confidence. Four marine shells overlying the Taupō tephra or equivalent unconformity at Ahuriri Lagoon yielded a combined (OxCal 4.4 R_combine) date of 411 ± 100 CE, which includes the wiggle match date at 95% confidence (219-610 CE) but is from a setting where carbon recycling is both to be expected and evident in conflicting ages on peat and shells. All three stratigraphies indicate that the Taupō eruption was associated with abrupt uplift. Previous studies show that Ahuriri Lagoon subsided abruptly at the time of the eruption: our reanalysis of beach stratigraphies implies that an earthquake almost contemporary with the eruption, previously attributed to upper plate faulting, uplifted Table Cape, Pakarea River mouth, and Puatai Beach. Turbidite stratigraphy indicates that regional slope failure associated with the earthquake entrained the Taupō Tephra and therefore followed it. Sedimentation rates and the clean stratigraphic break in tephra context at the beaches suggest that the earthquake occurred years to a few decades after the eruption, synchronously triggering regional turbidity currents. These associations imply that caldera-forming eruptions may trigger subduction thrust activity.

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Decadal scale changes in flood frequency over the past 2600 years from an annually resolved sediment record from Lake Ohau

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6C: Climate, C3, November 24, 2020, 2:30 PM - 4:30 PM

In 2016 the Lake Ohau Climate History (LOCH) project cored an 80 m, 17,500 year-long sediment record from Lake Ohau (~Lat. -44.23; Long 169.85). Radiocarbon dates on leaves, twigs and Cladocera ('water fleas') show the average sedimentation rate is ~7mm/year for most of the Holocene, but slows to ~3mm/year prior to that. Computed tomography (CT) images capture downcore variability in density at sub-mm resolution. Density at this scale is controlled by porosity and seasonal changes in the grain size of sediment accumulating on the lake bed. The summer/winter density couplets can be overprinted by periodic summer inflow 'events'. Notably, particularly large floods leave a distinctive density pattern in the core and a significantly thicker-than-average annual layer. Focussing on the last 2600 years, we have used bespoke algorithms to divide the density record into annual layers and identify the occurrence of large flood deposits. Preliminary analysis of these results suggests a strong modulation of the flood frequency by the Interdecadal Pacific Oscillation (IPO). Spectral analysis of the density time series also shows periodicities consistent with the El Nino-Southern Oscillation and variability in solar output, suggesting these climate modes and drivers may also modulate catchment precipitation and inflow into the lake on decadal to millennial timescales.

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Interpreting Geological structures from Gravity and Magnetic data, Northland, New Zealand.

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

In order to understand the potential of Northland in terms of mineral deposits, we first need to tackle its tectonic complexity at different scales. The publicly available gravimetric and aeromagnetic datasets across Northland provide opportunity to explore geological structures that may be associated with mineralisation at two scales of complexity. Evidence of tectonic orientations and possible depths to geological structures provide the geologic framework to think about the location of current prospects in Northland and those that might be of interest in the future. We will show preliminary results on the depth to source and orientation of structures by means of the Euler Deconvolution geophysical technique. The application of the technique and its pitfalls will be discussed, specifically the choice of a Structural Index and window sizes, along with the chosen clustering technique that provides a way of organizing the most reliable results guiding the interpretation and its geological significance. Computational tools for freely integrating and visualizing the results using the Python programming language, along with available datasets from the New Zealand Petroleum and Minerals website and the GNS geological map layers, will be demonstrated. These tools allow sharing research outcomes that foster reproducibility among peers and can be excellent teaching tools that level the ground for those without access to proprietary GIS tools..

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New Puzzle Whale Pieces Together Past Phylogeny

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1A: Unravelling the Seascape, C1, November 23, 2020, 11:00 AM - 12:00 PM

Many fossil baleen whales or mysticetes have been found in New Zealand's Waitaki valley. OU22404 is a distinctively new genus of whale. Its skull measures just over 1.5 m, based on the length of the mandible, giving a body length of 5-6 Metres. It was collected from Island Cliff near Tokarahi, North Otago. OU22404 is from the Otekaike limestone, upper Waitakian (G. connecta zone) at about the Oligocene-Miocene boundary.

The fossil has a long, gracile, bowed lower jaw, and toothless upper jaw which in life carried many flexible plates of baleen used to filter food from the water. Phylogenetic analysis of the skull reveals that the species is more closely related to fossil Mauicetus and in turn to rorquals (blue whales, humpback whales, etc) than it is to right whales and pygmy right whales. OU22404 has both modern and basal characteristics that help us place it phylogenetically. “Modern” features include short neck vertebrae and a locked elbow joint, while “basal” features include long nasal bones and an anteriorly opening blowhole. The bowed lower jaw is consistent with an arched upper jaw, but the detailed jaw mechanism is uncertain. OU22404's ear bones are unique; the cochlear part is a teardrop shape, and the anterior process is small and squared, shapes uncertainly adapted for hearing and balance.

OU22404 confirms that rorqual-like species had appeared by the later Oligocene.

Field work; National geographic grant 5381-94

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Holocene temperature change as told by New Zealand glaciers

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Understanding pre-industrial or natural climate variability provides an important context for assessing the impact of anthropogenic climate change. However, detection and attribution of human impact on the climate system is limited by short instrumental climate records, especially in the Southern Hemisphere. Mountain glaciers are sensitive climate indicators, thus geological records of their past variability offer the potential to augment instrumental records.

Here we present a new cosmogenic 10Be chronology of length changes at Dart Glacier in the Southern Alps. Prominent moraines deposited 321 ± 44 yr ago (n=11) show glacier advances during the Little Ice Age were smaller than during the early Holocene (7.8 ± 0.2 ka; n=5). This pattern of net Holocene glacier retreat is consistent with emerging data from other catchments in New Zealand and across the southern mid-latitudes. Measurements of 10Be in bedrock surfaces uncovered by retreat of Dart Glacier over the last century yield minimal evidence for prior exposure, which is consistent with net glacier decline during the Holocene and may indicate a present-day glacial minimum for the interglacial.

Interpreting this climate proxy data in the context of existing global climate model simulations, we suggest that net decline of New Zealand glaciers through the Holocene was caused by rising summer air temperatures through the interglacial due to increasing summer insolation intensity – which is currently at its Holocene maximum. The current glacial minimum may have been pre-conditioned by orbital forcing of summer temperature and augmented in recent decades by radiative forcing effects of anthropogenic greenhouse gas emissions.

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Material properties, from seismic attenuation, influence multiple fault rupture and ductile creep of the Kaikoura Mw 7.8 earthquake, New Zealand

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6B: Transition Zone, C2, November 24, 2020, 2:30 PM - 4:30 PM

The 2016 Mw 7.8 Kaikoura earthquake occurred along the eastern margin of the transition region between active subduction in the North Island and oblique collision in the South Island. To infer crustal properties, we imaged Q (1/seismic attenuation) by combining selected M>3.5 aftershocks with previous data. The Qs and Qp results show features in the upper and lower crust which relate to the distribution and types of fault rupture. This earthquake involved numerous faults over a region of greywacke crust, where the underlying high Q Cretaceous slab is about 30-km depth. It initiated on the Humps fault in a region of background seismicity and low Q lower crust, adjacent to the Hope fault. The central region near Kaikoura shows a high Q crustal block, which appears to have inhibited rupture; as the rupture progressed over several small faults to jump offshore of the apparently strong block. Underlying Kaikoura, below 20-km depth, there is a 40-km long region of increased vp, Qs and gravity, which likely represents an intraplate plutonic complex emplaced into the Hikurangi Plateau, forming an elevated section which influences deformation. In the northern section, in a region with relatively uniform moderate to low Q, the earthquake evolved into the relatively continuous ~80-km long major rupture along the Jordan, Kekerengu and Needles faults. The northern progression of the rupture stopped when it approached an abrupt change to high Q crust across Cook Strait. At 20-30-km depth northwest of the rupture, deeper zones with low Q are consistent with regions of distributed ductile shear and creep where the observed afterslip may have occurred, where the underlying slab is 25-40 km deep. A numerical model shows that ductile deformation localises in this area of lower crust above the relatively strong slab, connecting outer faults (Kekerengu) to inland faults (Clarence, Awatere, Wairau).

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Exploring Auckland Faults

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The Canterbury earthquakes proved long recurrence interval and geologically/geomorphically obscured faults within urban areas can still represent significant seismic risk in New Zealand. In the Auckland region the geomorphically prominent but largely long and irregular recurrence interval Auckland Volcanic field has already garnered much scientific attention and urban development expands towards the known active Wairoa North Fault in the Hunua Ranges continually increases seismic risk. A programme of work is underway in the region to better characterise previously recognised faults and explore for obscured faults. Campaign geodesy indicated dislocation in the vector field trending northwards from the mapped Wairoa North Fault. Subtle vector dislocations also hinted at an additional NNE trending structure to the west of Auckland in the Waitakere foothills that is worthy of further investigation. A remote surveying morphotectonic analysis of the Auckland region utilising Lidar and satellite data mapped many lineaments with orientations consistent with dominant mapped fault trends. Structural mapping to ground truth geodetic dislocations, geomorphic lineaments and their implications for seismic hazard and geotechnical behaviours continues.

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Magma ascent rates at the onset of recent rhyolitic eruptions at Okataina Volcanic Centre, New Zealand.

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Determination of the initial magma ascent rates of past events provides a valuable estimate of the potential warning time a volcano may give between unrest and eruption. Okataina Volcanic Centre is one of two currently-live rhyolitic caldera systems in the central Taupō Volcanic Zone, New Zealand. Post-25.4 ka rhyolitic eruptive episodes, occurring along two linear vent zones (Tarawera and Haroharo), provide an opportunity to investigate likely magma ascent patterns and rates at a large, active rhyolite volcano, and to see if such rates vary between similar eruptive episodes.

Here we present FTIR-based volatile measurements and diffusion modelling of both sealed and open-ended melt inclusions in quartz from the first-erupted deposits of Okataina's most recent rhyolitic eruptions. We use these data to constrain the storage conditions and initial magma ascent rates prior to its eruptive activity. We have sampled material from eight eruptive episodes, to gain some insight into the overall patterns of magma ascent from source to surface and its variability.

Preliminary results suggest that sealed melt inclusions contain 4.5-5.7 wt% H2O and 28-42 ppm CO2, corresponding to saturation pressures of 1.2-1.7 kbar. Estimates of rise rates and overall magma ascent patterns (modelled from measured volatile transects through open melt inclusions) will have implications for what may be detected by monitoring systems prior to future activity. As part of the ECLIPSE research project we are working with end-users to quantify the risks associated with the TVZ's caldera volcanoes, and reduce the uncertainty surrounding them to enable better forecasting and emergency planning strategies. Rise rates from these past eruptions will contribute towards a better understanding of the expected anticipated warning time Okataina Volcanic Centre may give prior to its next eruption.

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*The emerging educational effectiveness of a virtual microscope and virtual demonstrator during the COVID-19 crisis.

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

From the 25 March – 27 April 2020, New Zealand was placed under lockdown due to the community transmission of the COVID-19 virus. As such, geology undergraduates at the University of Canterbury (UC) were unable to attend their weekly physical laboratory sessions. To cope with the situation, we developed the Virtual Microscope/Demonstrator (VMD), a two-part online platform which allowed students from the Rocks, Minerals and Ores (GEOL242) course to complete their laboratory work remotely during the lockdown period and receive feedback.

A virtual microscope (VM) and virtual demonstrator (VD) work together in the VMD to provide students with a laboratory experience as close to face-to-face as possible. The VM gives students remote access to samples by utilising interactive digital multimedia, such as microscope videos and images in conjunction with 3D hand sample rock models. Once students submit their laboratory work through the UC course management site, this same multimedia is used by the VD to provide students with feedback. The VD queries students in a similar fashion to a real demonstrator by posing questions such as “have you remembered to describe the mineral colour”, and “what property is this mineral exhibiting” to remind students of important diagnostic features. This guided learning provided by the VD is what sets the VMD apart from other online microscopes.

After their end of semester laboratory exam, students reflected on the VMD and how they performed in the exam by completing a questionnaire. Initial review of student feedback and data suggest that while the platform has room for improvement, students felt that the VMD was beneficial to their overall GEOL242 learning experience in the absence of face-to-face laboratory sessions.

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Reinforced Soil Bund as passive protection structures: the New Zealand Experience

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5B: Engineering Geology, C2, November 24, 2020, 11:00 AM - 1:00 PM

Reinforced soil structures are well known for their excellent performance in resisting external loads such as seismic shaking. The superior performance over rigid structures is due to the very ductile behaviour of the structures as a result of relatively closely spaced soil reinforcement inclusions in soil. The ductility of these structures is utilised in the field of very high dynamic impact energy of rock fall with an aim to protect infrastructure. Back to back reinforced soil structures or bunds are constructed with layers of reinforcement and suitable facing units designed to resist dynamic impact energy. Full-scale impact trials have been carried out on these structures in Italy and simplified design charts have been developed from there. Several of these reinforced soil bunds have been designed and constructed in Christchurch following the 2011-12 earthquake and in Kaikoura after the 2016 earthquake. This paper details case studies of 2 of these structures across Christchurch and Kaikoura in the South Island of New Zealand.

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Temperature and strain controls on ice deformation mechanisms: insights from the microstructures of samples deformed to progressively higher strains at -10, -20 and -30 °C

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1C: Cryosphere, C3, November 23, 2020, 11:00 AM - 12:00 PM

To better understand ice deformation mechanisms, we document the microstructural evolution of ice with increasing strain. Polycrystalline ice was deformed under a constant displacement rate (~1e-5/s) to progressively higher strains at temperatures of -10, -20 and -30 °C. Microstructural data were generated from cryogenic electron backscattered diffraction (cryo-EBSD) analyses. All deformed samples contain sub-grain structures with misorientation axes that lie dominantly in the basal plane suggesting the activity of dislocation creep (glide primarily on the basal plane), recovery and subgrain rotation. Grain boundaries are lobate in all experiments suggesting the operation of strain-induced grain boundary migration (GBM). "Core-and-mantle" structures occur in -20 and -30 °C experiments, suggesting that subgrain rotation recrystallization is active. At temperatures warmer than -20 °C, c-axes develop a crystallographic preferred orientation (CPO) characterized by a cone around the compression axis. We suggest the c-axis cone forms via the selective growth of grains in easy slip orientations by GBM. The opening-angle of the c-axis cone decreases with strain, suggesting strain-induced GBM is balanced by grain rotation. Furthermore, the opening-angle of the c-axis cone decreases with temperature. At -30 °C, the c-axis CPO changes from a narrow cone to a cluster with increasing strain. This closure of the c-axis cone is interpreted as the result of a more active grain rotation together with a less effective GBM. As the temperature decreases, the overall CPO intensity decreases, primarily because the CPO of small grains is weaker. High-angle grain boundaries between small grains have misorientation axes that have distributed crystallographic orientations. This implies that, in contrast to subgrain boundaries, grain boundary misorientation is not controlled by crystallography. Grain boundary sliding of finer grains or nucleation of grains with random orientations could explain the weaker CPO of the fine-grained fraction and the lack of crystallographic control on high-angle grain boundaries.

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Sea ice freeboard derived from satellite altimeter in the Western Ross Sea, Antarctica

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

To draw accurate conclusions on the sea ice mass balance it is vital to have precise knowledge of the sea ice thickness. In this study, we attempt to calculate the sea ice freeboard of pack ice from satellite altimeter data in the Western Ross Sea region. The sea ice morphology in this region ranges from simple land-fast sea ice to complex pack ice. In the study area, thin ice is potentially covered with the snow, which results in flooding and making it difficult to estimate the sea ice freeboard. In this study, both satellite-derived radar and lidar altimeter data have been utilized to estimate the sea ice freeboard. Cryosat-2 radar altimeter data are available from 2011 to 2019 and are examined. In September 2018, the Ice, Cloud, and land Elevation Satellite-2 (ICESat-2) laser altimeter was launched and a freeboard data product (ATL10) of 2019 is also available for comparison. This comparison between radar and laser for the overlapping year (2019) can be used to study the influence of snow on freeboard. Here we present preliminary results of the sea ice freeboard distribution across the study area and discuss the uncertainties and limitations of the data.
Keywords: sea ice freeboard, sea ice thickness, Cryosat-2, ICESat-2, Western Ross Sea

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Deep magmatic volatiles of the Taupo Volcanic Zone - insights from helium isotopes and CO2 abundance

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Magmatic volatiles are a useful tool for investigating magmatic processes throughout the crustal column and into the underlying mantle. In subduction zone volcanism, like the Taupo Volcanic Zone (TVZ), magmatic volatiles are derived from a combination of sources; including the mantle, the subducting slab, and the overlying crustal section. In addition, magmatic volatiles make an important contribution to surface degassing. This study utilizes 3He/4He and CO2/He ratios in the Central and Southern TVZ using olivine and pyroxene phenocrysts from monogenetic basalts and pyroxene from a rhyolite. In addition, we present comparative results investigating potential He diffusive effects from high voltage electrical shocks during sample preparation using a Selfrag Lab System.
Preliminary 3He/4He measurements of Central and Southern TVZ olivine and pyroxene from Rotokawau, Ongarato, Poronui and Waimarino range from ~4.7 to 6.4 RA, overlapping with previously published values from the same areas[1,2]. The values are lower than those associated with NZ intraplate volcanism as observed in the Auckland Volcanic Field (~7 RA). Previously published 3He/4He and CO2/He ratios from geothermal fluids suggest a westward increasing 3He/4He ratio (up to 7.4 RA) and decreasing CO2/He ratio[2]. Our preliminary data show less variability than observed in the geothermal fluids and lack 3He/4He ratios > 6.5 RA, suggesting possible separate sources of gas, or crustal contamination of basaltic magmas.

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Reservoir and seal properties of volcaniclastic deposits from the Kora Volcano, offshore Taranaki Basin, New Zealand

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3C: Petroleum, C3, November 23, 2020, 4:00 PM - 5:30 PM

Kora Volcano is a large (>50 km3) deep-submarine Miocene stratocone, buried by over 1000 m of sedimentary strata, and imaged by 3D seismic reflection surveys in offshore Taranaki Basin. Kora hosts a sub-commercial oil discovery within syn- and inter-eruptive volcanoclastic deposits including tuffs, breccias, epiclastic sandstones, and volcanic conglomerates with variable porosity and permeability (<3-35% and <0.1-1000 mD). This study investigates the origin, reservoir potential and seal capacity of a volcaniclastic sequence perforated by two petroleum exploration wells, Kora-2 and Kora-3, located on the crest and flank of the volcano.

Petrographic, petrophysical and SEM-EDS analysis indicates the rocks contain a matrix of microcrystalline calcite (micrite) and equant calcite spar cement, suggesting that cementation and loss of original porosity occurred during seafloor accumulation and early burial. Cathodolumiscence testing suggests the composition of carbonate material filling pores and fractures belong to a single period of early diagenesis.

Below 1800 m, an iron sulphide (pyrite) precipitate typically replaces the microcrystalline calcite matrix. The iron sulphide and carbonate cement unlikely results from hydrothermal fluids, due to visible preservation of fossils and lack of changes in the rock fabric.

The iron sulphide precipitate and calcite cements infill most original porosity, resulting in a volcaniclastic rock with low porosity and permeability (<6.32% and <0.02340 mD). Fractures and calcite veins are common and occasionally, oil is visible infilling fractures in both cores and thin sections. These fractures likely result from both brittle deformation during early burial stages and fracturing from fault activity.

Results from this study suggest that inter-eruptive epiclastic rocks deposited in a submarine environment have little potential to form reservoirs for hydrocarbons and other fluids. Instead, these rocks, if unfractured, may form efficient seals. This study demonstrates the value of petrographic and petrophysical analysis to increase understanding of processes controlling formation of volcanic reservoirs.

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Engineering Geology Industry-Academia Partnerships: Experiences from the UC Quake Centre Dams Project

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8A: Geo-Teaching & Practice, C1, November 25, 2020, 11:00 AM - 1:00 PM

The primary aim of the taught Professional Masters in Engineering Geology (PMEG) at University of Canterbury is to prepare students for employment in the geotechnical profession. The course content is designed to lead towards successful accreditation as a professional engineering geologist. The focus of the course is ‘hands-on’ practical experience in various aspects of engineering geology practice including the generation of engineering geology models; site investigation philosophy, methods and practices; principles and practices of rock and soil mechanics; geohazard evaluation and mitigation; construction materials and construction practices; and groundwater occurrence, behaviour, resources and remediation. The culmination of the programme is an independent research dissertation where the PMEG students are partnered with industry to investigate real world geotechnical problems. The University of Canterbury (UC) Quake Centre Dams Project has been used as a vehicle for providing dissertation projects aligned with New Zealand’s energy industry. With a focus on assessing the integrity of earth embankment dams and canals and evaluating the impact of an array of geohazards on energy infrastructure, the students develop practical investigative and problem-solving skills in both the field and the laboratory. At completion of the dissertation project the students have developed the ability to critically assess and synthesise prior project data, as well as accumulating knowledge and understanding of contemporary issues and modern engineering concepts. The resulting dissertation reports allow industry to make informed decisions on repair and maintenance strategies and allow prioritisation of geohazard mitigation measures.

A Compilation and Characterisation of Lithic Populations in Maar Ejecta Rims and Diatremes

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Maar-diatreme volcanoes are the second most common type on land, and are present in volcanic fields within all major tectonic environments. Current understanding of subsurface processes in maar-diatreme volcanoes makes it a challenge to understand how large, deep-sourced lithics are erupted to the surface, and also what information can be extracted from lithic populations as a whole.

Explosions are traditionally considered to occur only at the base of a diatreme, with a progression downward governed by a cone of depression in the host aquifer. Recent experimental and field studies, however, highlight the presence of explosion sites at a range of horizontal and lateral locations within diatremes, with heterogeneously distributed water throughout. Field studies of kimberlite diatremes offer two models, one consistent with that for non-kimberlite diatremes, and another in which volatile-rich magma forms a sustained eruptive jet, often associated with wholesale fluidization within the diatreme.

In order to understand the physical nature of these eruptions, it is necessary to characterise the lithic populations in the deposits. We are carrying out a comprehensive compilation from published accounts of lithic abundances, sources, and shapes in maar ejecta rims, and also in diatremes of both kimberlite and non-kimberlite sites around the world. We intend to interrogate the completed compilation for systematic patterns that can be used to infer physical eruptive processes or histories.

Preliminary results for maar-diatremes and tephra ring deposits show no correlating trends between sizes, shapes, depositional sites, and excavation depths of lithics. This may reflect gaps in the reporting of lithics; for example, many studies do not report on the shapes or rounding, and many studies do not report on the depths of excavation. Further work will include separately analysing subsets of compiled data, screening for data quality and other attributes.

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Fossil dolphin diversity in the Otekaike Limestone

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The Otekaike Limestone of the Canterbury Basin is a richly fossiliferous, marine mid-shelf formation, mainly a bioclastic calcarenite, that spans the upper Duntroonian and Waitakian Stages. The limestone is notable for the abundance of fossil vertebrates, particularly cetaceans (dolphins, whales), penguins, bony fish, and sharks. The most productive locality is Hakataramea quarry. The vertebrates are generally dated using Jenkins' planktic foraminiferal zones. In particular, the G-connecta zone helps to recognise the earliest Miocene Aquitanian International stage, an interval of puzzling low diversity globally.

Since 2000, informative new species of dolphins have been recognised and named from the limestone in the Waitaki district. These often-well preserved specimens may typify natural groups, and in turn help to understand form, function, feeding habits, habitats, and evolution. Of note:
Waipatia dolphins have a low skull with differentiated teeth (procumbent tusks grading back to serrate crowns);
Otekaikea dolphins have a skull with a high crest that anchors the echolocating muscles;
Shark-toothed dolphins are large (skull to 1 m long) with robust triangular teeth for bone-shearing;
Archaic ocean dolphins have a rounded brain case and multiple robust conical teeth;
Needle toothed dolphins have fine long teeth for securing small fast prey; and
Suction feeding dolphins with few or no teeth take soft bodied prey.

The diversity of dolphin groups is a proxy for habitat and prey. Presumably the Late Oligocene shelf seas of Zealandia varied in sediment, current systems - especially upwelling, and temperature regimes. By analogy with the modern North Pacific, Late Oligocene cetaceans were important "ecosystem engineers", ensuring wide transfer of nutrients in the waters of Zealandia and the adjacent Southern Ocean.

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Geochemical Mapping of Aotearoa New Zealand's Marine Sediments

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Surficial marine sediments are highly diverse in composition as they are influenced by many physical and chemical processes, including biological activity, seafloor volcanism, and the presence of mineral resources. This diversity is reflected in their bulk chemistry; however, the geochemical characterisation of Aotearoa New Zealand's seafloor sediments is very limited.

Here, we present the first step towards characterising the chemical properties of Aotearoa New Zealand's marine sediments using a local study in the Bay of Plenty. Over 250 samples have been analysed for a selection of major and trace elements using portable X-ray fluorescence (XRF) spectrometry. The geochemical data were calibrated using internal standards, and cross calibrated with other energy dispersive and wavelength dispersive fusion XRF analyses and the measurement of Certified Reference Materials. The developed calibrated technique for portable XRF measurement of marine sediment is more cost effective than using traditional XRF methods and enables greater numbers of samples to be analysed in a short amount of time.

The quantitative chemical maps produced in this study build on previous work on Aotearoa New Zealand seafloor grainsize and carbonate distributions (Bostock et al., 2019a, 2019b). Together these datasets have practical applications such as monitoring the distribution and movement of sediment, chemical changes due to anthropogenic activities such as ocean acidification, and identification of mineral resources.

Bostock et al., (2019a). Distribution of surficial sediments in the ocean around New Zealand/Aotearoa. Part A: continental slope and deep ocean. New Zealand Journal of Geology and Geophysics, 62(1), 1-23. Retrieved from https://doi.org/10.1080/00288306.2018.1523198. doi:10.1080/00288306.2018.1523198

Bostock et al., (2019b). Distribution of surficial sediments in the ocean around New Zealand/Aotearoa. Part B: continental shelf. New Zealand Journal of Geology and Geophysics, 62(1), 24-45. Retrieved from https://doi.org/10.1080/00288306.2018.1523199. doi:10.1080/00288306.2018.1523199

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Science into policy: The role of relationships in effective natural hazard science communication

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1B: Hazards Symposium, C2, November 23, 2020, 11:00 AM - 12:00 PM

Central and regional government decision makers are key stakeholders for natural hazards research in New Zealand. Healthy and well-established relationships between science and policy makers facilitate pre-disaster risk mitigation and better post-disaster recovery. Two-way communication is key to this outcome. Effective utilization of the New Zealand science system requires communication of needs from endusers to scientists, communication of results from scientists to endusers, and clear communication of opportunities in both directions. Exceptional science advice communication pathways and relationships currently exist in New Zealand and have been utilized over the past decade to help the nation recover from earthquakes and volcanic eruptions, respond to tsunamis, prepare for climate change and sea level rise, and recently, to battle the global Covid19 pandemic.

Shared understanding of scientific uncertainty is an especially challenging but necessary cornerstone of this science-to-society process. We as scientists typically have a good understanding of the roles of aleatory and epistemic uncertainty underlying our models. Unfortunately, we sometimes struggle to communicate these uncertainties to endusers. When, for example, providing enduser advice based on stochastic models, it is important that endusers understand the probability distribution of model results. Laying the groundwork for communicating this scientific content before disaster strikes is invaluable. While not obvious, but extremely critical, it is also necessary for scientists to understand the goals of endusers in order to best analyze and present results, and even in order to design the most useful experiments. In this talk, we will explore these concepts by presenting case studies from New Zealand earthquakes and recent preparedness initiatives.

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NZ DART array and tsunami early warning

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4B: Hazards, C2, November 24, 2020, 8:30 AM - 10:30 AM

Led by a cross-agency central government and CRI effort, New Zealand has deployed an array of ocean-bottom pressure recorders (DARTs) that transmit near real-time tsunami information to underpin tsunami early warning efforts in New Zealand and the greater southwest Pacific. We examine the sensitivity of this tsunameter array for tsunami early warning by analysing its ability to underpin tsunami forecasts for historical events ranging in magnitude from 7.4 to 8.0 with locations along the Kermadec and Tonga trenches. For these events, we invert synthetic DART wave recordings for tsunami source on a series of 100km X 50km fault patches representing the Hikurangi, Kermadec and Tonga subduction zones and outer rises. We use hard- and soft-exclusion approaches to limit the fault patches available in the inversions. We then compare forward tsunami simulations from these tsunami sources with forward modelled tsunamis from the USGS NEIC finite fault earthquake source for each earthquake. We present evidence that reasonable coastal tsunami forecasts for these events are possible with the DART network and existing inversion framework, and in most cases within 20 minutes of the earthquake origin. Note, this is a scientific timeline and does not consider logistics of the information flow in the practical delivery of warning to coastal residents. We note that for some cases, forecasts underpinned by w-phase seismic inversion perform better than those with no a-priori seismic moment-tensor information.

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Copper mobility in the near-surface environment from hematite-goethite-hosted Cu-Au mineralisation, Katoka, Zambia

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7C: Minerals, C3, November 25, 2020, 8:30 AM - 10:30 AM

Geochemical data from Cu-Au mineralisation at Katoka, Central Zambia show that high Cu concentrations in the in-situ mineralisation are not reflected by Cu contents of soil that directly overlies it. Microcharacterisation of the in-situ mineralisation shows that Cu is hosted in three phases: (1) in goethite; (2) as native Cu, and (3) as very fine chalcopyrite (<10 µm grains) in quartz. From each of these phases, Cu is not accessible to meteoric water of near-neutral pH. Which may explain why Cu concentrations in the soil above and adjacent to the in-situ mineralisation are much lower than typically expected.

Without characterisation of these samples using the Maia Mapper and SEM, these observations would not have been apparent and the exploration programme may have proceeded on the assumption that sampling fine (<180 µm) soil fractions would have been the optimal sample media. Instead, the coarser fractions of the soil respond better with higher Cu (and other pathfinder element concentrations). The microcharactersion provides insights into the reasons for this. Bismuth Sn, Te and Au which were identified as discrete phases in the in-situ mineralisation, and they are largely enriched in the soil profile nearer the surface.

Taken together, the data presented here show that with a judicious choice of (unconventional) sampling media, and laboratory analysis (i.e. high-sensitivity techniques), pathfinder elements can be used to map the extent of buried mineralisation. However, pathfinder elements need to be interpreted carefully and using multiple elements together. This approach provides confidence that soil sampling can play a role in the generation of drill targets in the Katoka area. This study underscores the importance of orientation surveys and the opportunities for early-stage exploration projects to utilise large-area mapping techniques, such as the Maia Mapper, to drive geological understanding near the start of an exploration programme.

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Reservoir surveillance and its impact on Māui gas-condensate field development since 1979.

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Throughout its development and operation, the Māui field has benefited from the gathering of surveillance data to monitor the impact of ongoing field production on the reservoir state. Well logs, seismic surveys and the results of well recompletions and workovers have all been incorporated into subsurface 'models' over the years (where the term 'model' is used in its widest sense, to encompass everything from conceptual mental models all the way to sophisticated suites of full-physics dynamic computer simulations). Those surveillance data have, at various junctures over the decades since the field started production in 1979, provided key insights into the behaviour of the field that have led to various additional development drilling projects. Those projects, in their totality, have extended the life of the field far beyond that envisaged in the early days of development, and ongoing surveillance continues to provide insights that allow field development to be sustained into the future.

This paper will discuss the specific impact of innovations such as time-lapse seismic surveys shot in 1991, 2002 and 2018 and their integration into a wider set of surveillance data that the Māui field owners have used to steer the asset's development, including recognising the opportunity presented by gas contained within areas of the reservoir that were not prioritised during initial development planning. It will show how the collective experience of the many geoscientists, engineers and drilling and operations staff that have worked on the asset over the years has been moulded by these data, which has in turn driven the successful adaption of development and operational strategies to keep the asset producing and contributing prominently to the effort to fulfil the energy requirements of NZ. This paper will show how these efforts are still bearing fruit, as exemplified by current and planned developments for the field.

The 2022 New Zealand National Seismic Hazard Model Revision

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8B: Active Tectonics, C2, November 25, 2020, 11:00 AM - 1:00 PM

We are currently embarking on the most significant revision of the New Zealand National Seismic Hazard Model (NSHM) in more than 20 years. In the past decades we have developed a significant amount of knowledge of earthquake occurrence and about how to model this occurrence in hazard models. An international team of more than 50 scientists is contributing to three working groups: 1) Seismicity Rate Models (SRM); 2) Ground Motion Characterisation Models (GMCM); and 3), Service Delivery (SD). Within the SRM and GMCM a critical focus is on understanding and modelling of uncertainty. Particularly, this is on uncertainty in our knowledge (i.e., epistemic uncertainty) that we can model via the use of alternative models in the NSHM. The SD group ensures we have the software and computational infrastucture in place to deliver the NSHM to those who need it.

In the SRM we will consider more ruptures than in past NSHMs. This includes complex multi-fault ruptures which were difficult to model in the past. While still possible to include, we will no longer by limited by strict fault segmentation and strictly characteristic earthquake behaviour. We will accomplish this using the USGS “inversion models” methods. Preliminary results are encouraging about our ability to apply this to the New Zealand fault system. This focus includes the Hikurangi subduction zone and the use of multiple recent data sets to constrain and better model the distribution of potential earthquakes on the interface.

GMCM will use multiple recent international ground motion models. Where feasible, and significant for hazard, regional adaptations to the models will be implemented. This includes necessary improvements for near-source large magnitude events and modelling of non-linear site response. As with the SRM, the Hikurangi is a critical focus of the model which requires better modelling of ground shaking from Auckland through to Wellington.

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Map-view restorations of the South Island, New Zealand: a new reconstruction of the last 10 Myr of evolution of the Alpine and Wairau faults

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8B: Active Tectonics, C2, November 25, 2020, 11:00 AM - 1:00 PM

The evolution of plate boundary faults transecting the South Island is reconstructed in map-view by retro-deforming horizontal and vertical displacements from the Quaternary (2 ± 1 Ma) to the Pliocene (5 ± 2 Ma) and Late Miocene (10 ± 1 Ma). Accrual of horizontal separation on the Alpine Fault is constrained by dextral offset of a system of N-S reverse faults correlated from Otago to the Glenroy-Matakitaki area, where they control the structure of the "bend". Accumulation of horizontal displacement was accompanied by a wave of exhumation and rock uplift that migrated NE-ward in the hanging wall of the Alpine Fault, tracked by lithology of clastic deposits within terrestrial syn-tectonic basins. Major implications of the reconstructions are: (1) present-day dextral separation of the Alpine fault is c. 410 km and the fault terminates south of the "bend". (2) Since the Pliocene, right lateral slip from the Alpine Fault was transferred to the Marlborough faults. The Wairau Fault is a structure distinct from the Alpine Fault, that offsets dextrally by c. 50 km the N-S Waimea-Flaxmore fault system of the Nelson region relative to equivalent reverse faults in the "bend". The N-S reverse faults were reactivated since the Pliocene to accommodate components of WNW-ESE shortening north of the tip of the Alpine Fault. (3) The dextral Marlborough faults reactivated sets of inherited normal faults during contractional rotation of the Australian plate above the Hikurangi subduction interface. The continuous transform system across the South Island was established post 2 Ma when the Hope Fault "captured" the Alpine Fault. (4) The tectonic discontinuity between the Alpine and Wairau faults does not favour propagation of coseismic ruptures from the Alpine Fault to the Wairau Fault through the "bend".

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Latitudinal migration of Southern Hemisphere westerly winds during the early Holocene

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6C: Climate, C3, November 24, 2020, 2:30 PM - 4:30 PM

The position and strength of the Southern Hemisphere westerly winds (SWW) influences precipitation patterns across the middle to high southern latitudes and plays an important role in the efficiency of the Southern Ocean carbon sink. Despite its importance in regulating climate little is known about the latitudinal position of the SWW belt in the past because reconstructions require multiple high-resolution records of SWW change from across a range of longitudes. Here, we use sediment cores from a New Zealand lake, subantarctic fjord, and Antarctic marine basin that were collected along a transect between 45 and 72°S, which bisects the wind belt in the southwest Pacific, to reconstruct changes in SWW strength and ultimately latitudinal location during the early Holocene (10.6 – 8.4 ka cal BP). In addition, these records can be correlated high-resolution climate records from South America and the Antarctic Peninsula to reconstruct early Holocene SWW geometry across the Pacific basin. Weaker winds are observed between 45 and 54° on both sides of the Pacific basin, while around the Antarctic continent, increased upwelling of warm deepwater is driven by stronger winds around 60°S. These observations are consistent with modelled changes in ocean and atmosphere circulation during the positive phase of the Southern Annular Mode (SAM) and indicate that during the early Holocene the westerly wind belt in the Pacific had migrated poleward and was restricted to the narrow band south of 54° as a result of positive SAM-like circulation. This new suite of climate records fills gaps in our knowledge of SWW behaviour and shows that synchronous climate change observed in the polar, sub-polar, and temperate regions of the Southern Hemisphere may have been driven by positive SAM-like circulation anomalies during the early Holocene.

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Late Quaternary reconstruction of South Island climate using Itrax XRF elemental profiles

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Located on the northern margin of the modern Southern Hemisphere westerly wind (SWW) belt, precipitation patterns across southern Te Waipounamu/South Island are strongly linked to the location and strength of the westerly winds. Despite the importance of SWW in driving local and regional hydrology, we lack high-resolution reconstructions of hydrological change and SWW strength/location that span the period since the Last Glacial Maximum. This information is crucial for predicting future changes in wind-driven precipitation, which will have significant impact New Zealand's agricultural and energy sectors. Using elemental profiles obtained from grab samples and sediment cores collected from Lake Von, southern Central Otago, we have developed a centennial to millennial scale record of hydrology and SWW strength the spans the last ~16 ka cal BP. Itrax XRF analysis of grab samples characterised changes in lake surface sediment composition with water depth and provided the foundation for interpreting downcore change in sediment composition. Sediment deposited in the littoral environment is dominated by K, Fe, and Ti and is captured by the first principal component (77% of the total variance). Using elemental proxies for lithogenic and biogenic input developed from XRF elemental ratios we show that there are two broad intervals between 6.4 and 3.4, and 11.6 and 8.4 ka cal BP that are characterised by low lake levels, with relatively higher lake levels between 8.4 and 6.4, and 12.8 and 11.6 ka cal BP. When compared to records obtained from higher latitudes and across the Pacific basin, we attribute changes in lake level to latitudinal migration of the northern margin of the SWW belt. When the SWW belt margin lies over southern New Zealand increased rainfall leads to high lake levels, while southward migration of the wind belt and reduced precipitation results in low lake levels.

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Informing Ramped Pyrolysis Radiocarbon Dating with Parallel Pyrolysis-GC-MS Analysis

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9C: Geochemistry, C3, November 25, 2020, 2:30 PM - 3:30 PM

The depositional age of Antarctic sediments is often obscured due to the presence of reworked carbon associated with the detrital sediment. The Rafter Radiocarbon Laboratory has recently established a ramped pyrolysis system to improve radiocarbon measurements of difficult-to-date sediments and soils, including Antarctic detrital sediment. Our ramped pyrolysis technique exploits the thermochemical stability of distinct organic carbon pools present in a given sample, allowing more labile authigenic carbon to be separated from refractory components to obtain more reliable chronologies. Ramped pyrolysis is thus an intermediate technique between bulk and compound-specific radiocarbon analysis, giving more accurate information than bulk sediment dating without the cost and major technical challenges associated with compound-specific radiocarbon dating.

The ramped pyrolysis technique requires radiocarbon measurement of multiple pyrolysis temperature fractions to identify the youngest age which is assumed to be representative of the depositional age. The youngest age predominantly coincides with the most labile lower temperature fractions. Yet the requirement for multiple radiocarbon measurements can be cost prohibitive for comprehensive downcore dating. Thus, we have coupled ramped pyrolysis radiocarbon dating with pyrolysis-gas chromatography-mass spectrometry (Py-GC-MS) as a novel application for carbon source identification. Py-GC-MS identifies the compound classes present in each temperature fraction and allows us to discern the desired fractions that are representative of deposition. Early results confirm the presence of short chain n-alkanes indicative of marine carbon deposition in more labile, low temperature fractions, while diagenetically stable aromatic carbon structures constitute older, higher temperature fractions that skew the bulk age from the depositional age. By combining Py-GC-MS identification with ramped pyrolysis, the most suitable temperature fraction with carbon compounds representative of depositional age can be selected for radiocarbon dating, thereby shortening run times and reducing measurement costs to achieve more comprehensive downcore chronologies.

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How positive or negative accelerations associated with Earth's motions bring to life forces which displace tectonic plates

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

According to current publications, scientists are still not sure what moves plates. Some believe that one of the leading reasons for plate movement is thermal convection, others that "plate pushing and pulling", or "differences between plate displacement and its buoyancy", or "plate subduction". However, each such presumptions usually ends with honest statements like this or similar: "The mechanisms driving plate motion and the Earth's geodynamics are still not entirely clarified". One of the reasons for lack of clarity is that scientists do not recognize the accelerations generating the forces that move the plates. This study is based on the fundamental laws of physics and current discoveries from other disciplines. It reveals that by recognizing the accelerations (or decelerations) of the Earth or its part, we can identify the forces acting on plates. Having that knowledge, only then can we begin to draw the right conclusions and build computer programs that stimulate tectonic movements.

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Geomorphology and geotechnical characterization of the Queenstown Hill landslide

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5B: Engineering Geology, C2, November 24, 2020, 11:00 AM - 1:00 PM

The slopes surrounding the Queenstown area are predisposed to instability due to over-steepening of ice-carved slopes and inherent weaknesses of the Otago Schist (foliation, shears, lithotypes and discontinuities). Due to population growth and increased tourism, the pressure for residential expansion has resulted in an increased number of development proposals on the lower slopes of Queenstown Hill. This study investigates the geomorphology and geotechnical properties of the Queenstown Hill landslide by field mapping on 1 m lidar, paired with rock mechanics testing of the underlying schist.

The landslide is a deep-seated compound translational rockslide comprising quartzofeldspathic and semi-pelitic schist with an average foliation attitude dipping parallel to the slope at 15-35° SSW. Geomorphic mapping identified five zones based on distinct surface morphologies: (1) a joint controlled headscarp; (2) the main landslide body with a subdued hummocky topography and well established drainage; (3) an extensional zone characterized by a graben and large tension cracks (> 5 m deep, up to 100 m long); (4) a reactivation zone interpreted as a separate phase of movement; (5) a complex undulating toe zone bound by compressional features and subdivision development.

Laboratory results indicate a low porosity (3.0 %) and a weak to moderately strong compressive strength (11.3 - 61.8 MPa) with low deformation modulus (0.9 - 41.1 GPa). Testing of the physical and mechanical properties of the schist lithotypes showed significant variations in geotechnical properties demonstrating a clear relationship between mineralogy and texture. The lithological variations of the schist and geomorphic setting are likely to have a direct geotechnical influence on slope stability and foundation design, which is supported by kinematic analysis. The results of this study were used to produce a detailed ground model, which can be used to carry out numerical modelling.

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Emergence of critical climate states during the Plio-Pleistocene

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5C: Climate, C3, November 24, 2020, 11:00 AM - 1:00 PM

During the Plio-Pleistocene (approximately 5 Ma to present) glacial to interglacial climate variability evolved from dominantly 40 kyr cyclicity (Late Pliocene and Early Pleistocene) to 100 kyr cyclicity (Late Pleistocene to present). This period has been studied intensively, with the majority of research addressing three key questions: 1. Why did the dominant frequency of climate oscillations change, given that no major changes in orbital forcing occurred? 2. Why is the late Pleistocene climate characterised by 100 kyr cyclicity when astronomical forcings of this frequency are so much weaker than those operating on shorter periods? 3. Why are the longer glacial cycles of the Late Pleistocene characterised by a more asymmetric form with abrupt terminations? Deterministic models of Plio-Pleistocene climate evolution that have attempted to explain these changes have proposed a number of solutions, but these often differ from one another, suggesting that some piece of the puzzle is still missing. Here we investigate these first-order questions in a new framework, taking insights from the biological as well as physical sciences, and present a new analysis that both extends and complements existing theory. To do this, we first describe the structure of asymmetric Late Pleistocene climate cycles and use a non-linear dynamical systems approach to interpret their characteristic shape. Next, using insights from statistical mechanics we employ a cellular automaton model to investigate how this asymmetry may emerge naturally from an initial state of symmetry as system complexity increases. Finally, network theory is used to explain how abrupt glacial terminations may arise as a consequence of progressive synchronisation within the climate system – a process that also helps explain the emergent dominance of the 100 kyr insolation cycle.

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Fast ice over the McMurdo sound: Implications for Erebus Ice tongue dynamics.

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Ice tongues are extensions of Antarctic outlet glaciers floating at sea. Exposed to the ocean and atmospheric processes, they are sensitive to climate-related environmental change. Notably, it has been found that sea ice, such as land-fast sea ice, can have a stabilizing effect over ice tongues, and its seasonal duration can be an important factor on ice shelf disintegration. In this study, we look at seasonal patterns between fast ice and ice tongue interaction and present an analysis of the impact on Erebus ice tongue in McMurdo Sound.

Interferometric SAR (InSAR) and offset tracking techniques are used to obtain ice deformation and surface velocity products. 107 Sentinel-1 SAR images acquired between 2017 and 2020 with a 12-day repeat pass are used. Maps of land-fast ice area are obtained from InSAR coherence images. This allows for stabilized ice between scenes to be identified as long as the coherence is retained. In addition, a time series of ice velocity for the Erebus ice tongue is constructed and the dynamic interaction with sea ice is shown. Inference of fast ice volume from ICESat-2 satellite altimeter data for 2019-2020 is investigated in view of ice dynamics.

This presentation highlights the progress in a PhD study based on satellite remote sensing data and the progress already achieved in understanding Antarctic ice tongues as an indicator of environmental change

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Why so deep? Seismic imaging of the sedimentary infill of Otago Harbour reveals a >150-m-deep record of Quaternary environmental change

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Otago Harbour is an isolated coastal inlet carved by erosion into the 16-11 Ma Dunedin Volcano. During Quaternary lowstand periods, with sea level about 120 m lower than now, the harbour valley was subaerially exposed and fluvial processes deepened the basin that cut through the volcano. In contrast, during highstands, flooding of the harbour led to sedimentary infill of the basin with sediments that are primarily sourced from long-shore drift (primarily quartz-rich sands transported north along the coast from river mouths to the south) or from biogenic processes (e.g., shells of coastal organisms). Very little of the modern sediment in the harbour comes from the proximal rocks of the Dunedin Volcano.

Seismic imaging of sedimentary units relies on contrasts in physical properties between strata that produce reflections at the interfaces. Such reflectors can develop as a result of changes in depositional patterns, e.g., at boundaries within interbedded estuarine silt (mud) and sand layers, with varying amounts of carbonate. In the case of Otago Harbour, consider the effect of a hiatus during a period of overall sea level rise; sedimentation would slow down resulting in a decreased coarse-grained fraction in the sediments and an increase in carbonate production from near-shore biological communities. Drilling is needed to confirm the specifics of such relationships.

We present high-resolution seismic data (boomer source, 24-channel micro-eel receiver) collected since 2016 over much of the shallow regions (<2 m water depth at high tide) of Otago Harbour that image a >150-m-deep paleovalley, >30 m deeper than lowstand sea levels. Distinct sub-horizontal surfaces within the paleovalley terminate on the erosional flanks of the paleovalley that was carved down into the basement rock units underlying the Dunedin Volcano. These reflections can be interpreted as depositional sequences that record the paleoenvironmental history of the inlet as the sediments were deposited.

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Documenting some of what we learned from mitigating rockfall risk following the 2016 Kaikoura earthquake

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5B: Engineering Geology, C2, November 24, 2020, 11:00 AM - 1:00 PM

Landslides and rockfalls caused by the 2016 Kaikoura earthquake caused significant damage to and threatened critical road and rail infrastructure. Various measures were used to mitigate rockfall risk to the infrastructure and the people who use it.

Helicopter sluicing was a key method used following the Kaikoura earthquake to quickly clear unstable debris from slopes and allow recovery works to be undertaken more safely. It is believed that this was the largest sluicing project undertaken anywhere in the world. Very little published information currently exists about sluicing. Anecdotal feedback indicates sluicing was very effective in many cases and less so in others; in a few cases it may have even worsened the situation.

Use of temporary rockfall protection in New Zealand has increased significantly as a result of recent earthquakes in Kaikoura and Canterbury. In some locations, temporary protection measures have remained in place for up to 5 years to mitigate risks to people and infrastructure during recovery works until permanent solutions can be installed. Due to its temporary nature, and because it may be deployed rapidly in response to an event, there is often limited input into design. Impact capacity and performance is generally not well understood.

A research project, funded by the University of Canterbury Quake Centre and the New Zealand Transport Agency, has been undertaken to document the experience gained and lessons learned from these two lesser-documented aspects of rockfall risk mitigation. This work will aid future projects aimed at mitigating rockfall risks to people and infrastructure within New Zealand by allowing all parties involved to benefit from past experience, repeating successful practices and hopefully reducing the likelihood of repeating those that were less successful. This has the potential to save time and money on future projects, while enhancing health and safety for workers and the public.

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Strain distribution and methane migration across a shallow subduction splay fault at the Hikurangi subduction margin. A rock magnetic study on IODP Site U1518

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Lithostatic and tectonic compaction, together with the dewatering of clay-rich and porous sediments in young accretionary systems, usually results in the development of a sedimentary fabric, the alignment of clay-minerals along their shape preferred orientation.
We used rock magnetic techniques, including the Anisotropy of Magnetic Susceptibility (AMS) technique, and measurement of various remanence types, hysteresis loops and First-Order-Reversal Curves to study strain evolution and the locus of fluid and/or methane migration across a shallow subduction thrust fault near the deformation front of the northern Hikurangi Subduction Margin. Site U1518 of the International Ocean Discovery Program (IODP) penetrated hanging-wall (0-304 mbsf), fault zone (304-361 mbsf) and footwall domains of the Pāpaku fault, ca. 75 km east of Gisborne. The Pāpaku fault was proposed to represent a ramp-flat fault that formed due to the over-thrusting of compacted hanging-wall over younger seafloor sequences. AMS is sensitive to bulk orientation of the paramagnetic clay-fabric. Our results demonstrate that hanging- and footwall sequences experienced differing strain histories, and that strain decoupling occurs near the top of the fault zone. Anticipated E-W oriented lateral shortening in the footwall compares well to the local stress field.
To provide a constraint on potential loci of methane (and fluid flux in general) along the Pāpaku fault we studied the distribution of iron-sulfide minerals using magnetic property measurements in combination with backscattered electron imaging. Ferrimagnetic greigite, which is common in rapidly deposited marine sediments can be easily identified based on hysteresis and thermomagnetic properties. It is sensitive to changes in redox state, and easily breaks down to non-magnetic pyrite in the presence of methane and sulfate. The absence of greigite and an overall larger abundance of sulfide minerals near the top of the fault zone and in a narrow, sand-rich intervals indicate an increased accumulated and fault parallel methane flow.

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The present is the key to the past: an online resource for modern depostional systems

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4C: Sediments, C3, November 24, 2020, 8:30 AM - 10:30 AM

"The present is the key to the past", or the principle of uniformitarianism, relates to the study of the modern world to better interpret the ancient world. This is one of the fundamental principles of geology and assumes that the same natural laws and processes that operate today have always operated in the past. Typically, in the science of sedimentary geology, we attempt to decipher ancient environments by documenting rock characteristics in order to interpret their depositional setting. In particular, the ability to predict the nature and distribution of depositional systems is of paramount importance. Modern sedimentary environments and depositional processes provide broader views of the geometry and spatial distribution of these ancient deposits and provide a means to qualitatively and quantitatively describe and predict ancient rock body distribution in the subsurface.

In response to the general lack of readily accessible, digital, earth system modern-analogue datasets, the Sedimentary Basins and Te Riu-a-Māui/Understanding Zealandia Research programmes at GNS Science embarked on a four-year project to develop series of databases encapsulating sedimentological and stratigraphic parameters in modern depositional systems. Four terrestrial to marginal-marine depositional environments were chosen because of their relevance to past and ongoing research within New Zealand's sedimentary basins. The systems, comprising alluvial fan, fluvial, delta, and beach-foreshore settings, are relatively easy to access for modern study and contain a wealth of published data and associated imagery. We present an overview of these digital Modern Analogues databases, which are available on GNS's Petroleum Basin Explorer (PBE) web platform (https://data.gns.cri.nz/pbe/index.html). These quick look-up reference documents, with digital illustrations (diagrammatic and photographic), can be applied to a variety of research and commercial uses, and will be of use to anyone with an interest in sedimentology and/or terrestrial to marginal-marine environments.

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Do large earthquakes recur regularly, randomly or clustered together in New Zealand?

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8B: Active Tectonics, C2, November 25, 2020, 11:00 AM - 1:00 PM

Elastic rebound theory forms the basis of the standard earthquake cycle model, and predicts large earthquakes to recur regularly through cycles of strain accumulation and release. Long paleoseismic records from the Alpine Fault show one of the best examples globally of regular earthquake recurrence, as predicted by elastic rebound theory. This observed regularity gives us confidence to apply time-dependent models of future earthquake occurrence in earthquake risk mitigation efforts. However, many other New Zealand faults appear to rupture less regularly, although interpretation is hampered by the shortness of records. In this study we characterize the distribution of earthquake inter-event times from a compilation of well-studied New Zealand faults. We find that large earthquakes recur more regularly than a random Poisson process on most individual fault segments. The majority of New Zealand's well-studied faults show weakly periodic earthquake recurrence, consistent with the expectations of elastic rebound theory. The variability in length of successive inter-event times for most fault segments is uncorrelated, meaning future earthquakes probabilities depend on the long-term earthquake rate rather than the length of the previous inter-event time. However, some low activity-rate (annual rates < 2 x 10-^{4}) faults show clustered earthquake occurrence, which cannot explained by elastic rebound theory. These results for New Zealand faults are consistent with our analysis of a global population of paleoearthquake data.

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Forecasting tsunamis in New Zealand using precomputed scenarios database and DART observations

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9B: Active Tectonics, C2, November 25, 2020, 2:30 PM - 3:30 PM

We developed a tsunami scenario database with threat level maps for New Zealand from earthquake sources around the Pacific Ocean that can be used for tsunami early warning purposes. An earlier version of the tsunami threat level database was made in 2017. One of the main improvements is that we have greatly increased the number of scenarios in the new database. Scenarios now exist down to lower magnitudes for all source zones and we have included subduction zones near New Zealand in the database for the first time. The fault parameters for all scenarios have been updated based on the latest subduction interface models. Finally, we have also saved more data from each scenario than previously, including the tsunami travel times and tsunami waveforms at DART and tide gauge stations. These changes tripled the size of the database, from 336 scenarios to 998 scenarios, and provide much more information about each of them. At the National Geohazards Monitoring Centre, in response to a tsunami event, the earthquake magnitude and epicentre are used to select a threat level map in the database. Currently, a new New Zealand DART buoys network is being deployed in Southwest Pacific. Here we also present scaling relations that can be used to update the threat level map using tsunami amplitudes at the DART stations. We evaluate our new tsunami forecasting technique using a hypothetical scenario in Kermadec subduction zone and the 1960 Chile earthquake. The tsunami threat level maps from the forward tsunami simulation results of these two events are compared with the ones produced by our technique.

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Modelling rhyolitic magma storage: a reconsideration of analytical uncertainties when using rhyolite-MELTS geothermobarometry

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Rhyolitic magmas and their eruptions pose a significant hazard, particularly in New Zealand, due to their highly explosive nature and the potentially large scale of eruptions. Therefore, it is vital that we gain a better understanding of the conditions at which these magmas are stored prior to eruption. Currently there are several petrological approaches to estimating magma storage conditions. One popular technique is the use of "rhyolite-MELTS" to derive the crystallisation pressure for rocks that preserve glass compositions (either melt inclusions or matrix glass) representative of equilibration between melt, quartz, and one or two feldspars. This model has been used by many studies to investigate the evolution of shallow silicic magma systems and infer absolute and relative changes in storage pressure. However, the model has significant uncertainties, particularly those associated with the quality of the analytical data, that are often unaccounted for. Here, we present a redesign to the current rhyolite-MELTS geobarometer that does not modify the internal thermodynamic model but provides the user with a more intuitive and easy-to-use design. The new program also incorporates the ability to carry out Monte Carlo simulations based on glass compositions and the user-defined analytical uncertainties from secondary standards. More features will also be added to the new iteration of rhyolite-MELTS to enable faster and easier computations with batch computing a possibility. Compatibility is also an address that will be issued, with the new iteration of the program having the ability to be run from any computer with minimal setup. This new program is applied to existing and new sample data from representative Taupo Volcanic Zone rhyolites to gain new constraints on the ranges of model pressures with better uncertainty propagation through a range of Monte Carlo simulations.

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NZ DART network – updates and data access

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The tsunami monitoring capability of New Zealand/Aotearoa and the SW Pacific is taking a large step forward with the deployment of 12 Deep-ocean Assessment and Reporting of Tsunami (DART) buoys. This NEMA-led (GNS Science and NIWA supported) project will complement the existing Pacific-wide DART network, allow the early detection of potential local and regional tsunamis and provide information about distant-source events. These deep-sea measurements provide direct information about tsunami propagation and can be inverted for source mechanism. Allying this with our current and improving earthquake source characterizations and international tsunami warning efforts paves the way for significantly improved tsunami advice for NZ.

DART technology measures relative sea level heights via a Bottom Pressure Recorder (BPR), accurate to 1 mm and in water depths of up to 6000m. This data is communicated via an acoustic modem to a surface buoy, which transmits data via satellite communications. The 4G models deployed in the NZ network have a high sample rate and filtering to differentiate between the tsunami measurements and any potential earthquakes, allowing them to be deployed closer to source. Normal data transmissions have a sample rate of every 15 mins (communicated every 6 hours); event mode has a sample rate of 15 seconds communicated every 5 minutes. Upon collection of the buoys and BPRs, 1 Hz pressure and temperature data will be recovered.

GNS Science, through its role as DART data steward, has the responsibility of making sure DART data is available to the research community and scientific public. To that end, different DART data and metadata access mechanisms have been developed, alongside a roadmap for future improvements. The current state of the DART network will be presented (deployment dates and locations), as will some examples from the recently deployed buoys.

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Effects of organic matter complexation on partitioning of transition metals into calcite: cave-analogue crystal growth studies

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8C: Geochemistry, C3, November 25, 2020, 11:00 AM - 1:00 PM

Organic complexation strongly limits the free ion activity of transition metals (Co^{2+}, Ni^{2+} and Cu^{2+}) in cave dripwaters. This is hypothesised to limit metal availability, thereby creating a kinetic overprint on metal concentrations and isotope ratios in speleothem calcite. This study presents the results of the first cave-analogue crystal growth studies of transition metal partitioning in the absence and presence of organic ligands. The Geological Microclimate (GeoMic) system establishes homeostatic-control of air temperature and atmospheric pCO_2 (here 20 ±0.1 °C and 1000 ± 10 ppm, respectively), with additional regulation of relative humidity to cave-like levels (> 90%). Calcite was precipitated from flowing films on inclined glass plates to assess of the effect of prior calcite precipitation (PCP) on metal partitioning. We report speleothem-specific inorganic Kd values for Co, Ni and Cu of ~4, 1 and 44, respectively. Pronounced PCP effects were observed in Co and Cu in the inorganic experiments, leading to strong reduction in Cu/Ca and Co/Ca, whereas Ni/Ca molar ratios remained constant (within error). The introduction of the organic chelating ligand nitrilotriacetic (NTA) overturned the behaviour of Co and Cu, leading to progressive enrichment of solution Co/Ca and Cu/Ca ratios as PCP progressed and apparent Kd values below 1 for all three metals (also shown in a Cu-fulvic acid experiment). We show that in the presence of organic ligands with stability constants close to those observed in natural systems, the partitioning of transition metals into calcite is dependent on the fluid residence time and the dissociation constants of the metal-ligand complexes.

Basalt karst

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7A: Volcanism, C1, November 25, 2020, 8:30 AM - 10:30 AM

Karst is generally associated with solution features formed in dense carbonate rocks. Karst-like morphology sometimes also occurs on dense sandstone, granite or basalt. The world's best-developed basalt karst occurs in northern NZ, but is also known from Pacific Islands.
In NZ, basalt karst has been recorded from Pirongia northwards, being widespread on eroding Pliocene-early Pleistocene lava flows of Kaikohe-Bay of Islands and Puhipuhi basalt fields, with isolated occurrences in Miocene basalt of Ti Point and Mercury basalt fields and Pliocene Alexandra Volcanics. The youngest-known basalt karst is on Maungatapere lava flows, Whangarei field (Mid-Late Pleistocene). In NZ, advanced basalt karst morphology consists of "armchair basins" up to 1 m deep on the flat surfaces and fluting (up to 1 m deep) running vertically down the steep sides. Surface karst develops on fresh basalt boulder core stones and in-situ basalt on the eroding edge of plateau.

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Numerical modelling of tsunami hazards posed by explosive submarine volcanism

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Tsunamis initiated by volcanoes have the ability to greatly extend the primary hazard footprint of an eruption far beyond the proximity of the eruption itself. Around 26% of direct volcanic fatalities are attributed to these volcanogenic waves. Due to the limitations of volcanic observations, the understanding of the tsunamigenic potential of analogous subaqueous explosions and jets is poor. Data on explosions are limited to findings from largely dated, wartime naval field cases and the resultant empirically derived initialisation models. Numerical modelling promises to help expand knowledge of this source mechanism and investigate the hazard posed by waves generated by explosive submarine volcanism on coasts or around caldera lakes.

This work utilises two numerical methods: 1) A conservative axisymmetric, multiphase volume-of-fluid scheme; 2) A semi-discrete multilayer system. The first method is used to model the volcanic eruption and the generation of tsunami waves across the parameter space of water depth, bathymetric geometry and volcanic explosivity. Results from this will inform the suitability of different initialisation mechanisms which can then be used in the multi-layer model to propagate the waves into the far-field.

These methods are validated against escalating scale experimental series beginning at a laboratory flume investigation of instanced water columns, through to wave gauge records from a military test programme detonating 9250 lbs charges submerged beneath Mono Lake, California. Established empirical models are tested in two locales: Campi Flegrei west of Naples, Italy, and at Lake Taupō, New Zealand. This combined approach will help inform hazard implications of local area submarine volcanism.

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Plate coupling at the northern Hikurangi margin: new results from magnetotellurics

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

At the Hikurangi subduction margin along the east coast of New Zealand's North Island, plate coupling changes from weakly coupled in the northern part of the margin to locked in the south. Shallow slow slip events occur quasi-regularly in the northern weakly coupled part of the margin. In the last decade, magnetotelluric (MT) measurements have been collected at 408 locations along the margin to explore the relationship between the electrical resistivity of the subduction interface shear zone and plate coupling.
Our most recent field campaign (57 new measurements) covers the northernmost part of the Raukumara peninsula. These data show that the dipping conductor above the subduction interface imaged previously to the south is present beneath the entire Raukumara Peninsula and correlates with a large area of extensional strain rate consistent with weak plate coupling. The paucity of seismicity within 3km of the interface in the conductive areas of the plate interface corroborates our earlier interpretation that fluid and/or clay rich sediments are consistent with an area with a decreased density of asperities and stored strain.
While the conditions that lead to slow slip and changes in plate coupling are not fully understood, the presence of fluids within the subduction-interface-shear-zone are believed to play an important role. This belief is supported by the correlation we see along the Hikurangi margin between the resistivity at the depth of the plate interface in the MT data and the areal strain rate derived from GPS measurements. The correlation suggests that where plate coupling is weak, fluid and/or hydrated-clay rich sediments are abundant while where the plate coupling is strong or locked, the shear zone is thin and/or fluid and sediment poor.

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Seismogenesis Hikurangi Integrated Research Experiment (SHIRE): a lot has been happening in Middle Earth

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6B: Transition Zone, C2, November 24, 2020, 2:30 PM - 4:30 PM

The SHIRE project aims to aims to identify and quantify factors controlling the long-term evolution of the Hikurangi margin and the mode of slip along the subduction megathrust. Here we present an update on the seismology component of SHIRE, the relationship of SHIRE to other science projects focused in the region, summarise progress, and identify future Hikurangi margin projects.
The northern Hikurangi SHIRE project bookends the previous large-scale onshore-offshore southern Hikurangi SAHKE project providing data across contrasting interseismically locked segments of the plate boundary. Data for the seismology aspect of SHIRE were collected in two phases; between October 2017-April 2018 and, February-March 2019. In the first year, 46 temporary seismographs were located along a central transect between Gisborne and Ōpōtiki. Another 68 seismographs were distributed in an array throughout the Tairāwhiti / Raukumara Peninsula and along the Bay of Plenty coast. The instruments recorded sound sources from the R/V Marcus Langseth and recorded natural earthquakes during the four-month period. Offshore the Langseth collected 1443 km of OBS transect along four lines, and 4046 km of marine multichannel seismic (MCS) lines. In the second year, an array of 602 seismograph sites were deployed, along the central transect, to record five controlled borehole explosions. The explosions occurred during 26-28 February 2019, and the echoes recorded at each site add to the data collected in the first year.
The SHIRE dataset overlaps temporally and spatially with several other major Hikurangi subduction zone projects including NZ3D, SAFRONZ, HT-RESIST, BRANZ, IODP scientific drilling legs (372 and 375), and the ongoing HOBITSS deployments. A suite of field reports now detail SHIRE data sets http://dx.doi.org/10.21420/TQ67-8F60.

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New Zealand and IODP/ICDP: past, present, and future

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1A: Unravelling the Seascape, C1, November 23, 2020, 11:00 AM - 12:00 PM

Membership of IODP and ICDP international scientific drilling programs has facilitated high-profile, globally-coordinated Earth, Ocean, and Life science research in NZ over the last 12 years. NZ benefits greatly from the economies of scale of the pooled international resources of IODP and ICDP enabling access to world-class scientific facilities. The coordinated ANZIC geoscience community, for example, was the cornerstone behind six successful IODP expeditions in the NZ and Ross Sea region between 2017-20 resulting in a vastly improved understanding of earthquake processes along the Hikurangi margin, and higher resolution models of changing ocean and climate processes in the SW Pacific and Antarctica. The 2014 ICDP Deep Fault Drilling Project established a long-term monitoring observatory inside the Alpine Fault, providing scientific insights into how a large active strike-slip fault operates.
This year the IODP community has established a 30-year new science plan, **Exploring Earth by Scientific Ocean Drilling; 2050 Science Framework,** acknowledging the complementary objectives of ICDP and emphasizing interconnected research questions by focusing on understanding Earth's Natural Hazards, Cycles and Rates, and Health and Habitability. The Science Framework will also execute long-term Flagship Initiatives that range research efforts far into the mid-21st century and reflect society priorities in Future Climate Change, Ocean Health, and Assessing Earthquake Hazards to Society.
Given NZ's position astride the active Pacific-Australian plate boundary and as a gateway to the Southern Ocean, the region provides an ideal natural laboratory to host many of the Flagship Initiative Expeditions related to the physical processes that control geohazards, sea level change, past ocean and climate variability, and the geophysical, chemical, and biological character for exploring life and its origins. This presentation will summarize the accomplishments and challenges to allow our best emerging and established researchers to lead, influence scientific drilling, and enhance collaboration between NZ and the international community

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A seafloor analysis at locations of known gas hydrate expulsion, Wairarapa sector of the Hikurangi Margin.

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Marine gas hydrate research can be applied to a wide range of scientific issues, such as submarine landslides, climate change, ocean acidification and their potential as an alternative energy source. Natural gases such as methane are currently being considered as a “bridging fuel” that would be capable of aiding in a smooth transition to sustainable energy systems in New Zealand. While they can be considered as a potential energy resource, it is also important to acknowledge the implications associated with large scale methane release to the climate and the stability of the seafloor.

Bathymetric and backscatter data collected aboard TAN1808 has been used to characterise the seafloor above hydrate anomalies at five locations offshore southern Wairarapa. Seafloor sediment samples from this voyage, as well as data from the nzSEABED database, has been used in combination with the hydro-acoustic data to classify seafloor substrate. Geomorphic analysis reveals evidence for past seafloor instability, fluid seep carbonates, and sedimentary erosional and depositional features.

Image analysis delimited five distinct boundaries corresponding to backscatter reflectivity classes ranging from low to high reflectivity. A variety of seafloor morphologies were observed when a backscatter segmentation tool was applied to data. Areas of methane seepage appeared to have isolated high backscatter zones with high rugosity, whereas areas with a low seafloor relief had low-moderate backscatter reflectivity and was more widespread across the study areas.

This project is part of the HYDEE program and will aid in determining the sensitivity of the seafloor environment for potential hydrocarbon production scenarios, and if it would directly or indirectly impact seafloor stability.

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How do subsurface processes of faulting and fluid flow impact the seascape?

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3A: Unravelling the Seascape, C1, November 23, 2020, 4:00 PM - 5:30 PM

Across the southern Hikurangi Margin intensive deformation along the subduction zone has resulted in complex geomorphology of accretionary ridges interspersed with mini-basins. Processes of hydrofracturing, faulting, gas hydrate formation, erosion and ongoing sedimentation continuously alter the seascape, impacting geomorphology, slope stability and habitat distribution. Understanding how these processes interact in such a dynamic environment has implications for a wide range of research fields, such as marine geohazards, energy resources and ecological habitats.

The southern Hikurangi Margin is characterised by its complex structural and geological setting and the availability of extensive 2D seismic, sub-bottom profiler, and bathymetric datasets. This makes it an ideal region in which to study subseafloor fluid flow and hydrate formation and their impact on slope stability, climate change and potential as an alternative source of natural gas.
Here we focus on an accretionary ridge at the southern extent of the Hikurangi Margin, where convergence is highly oblique, resulting in a transition zone between subduction and strike-slip motion. At this site hydrate formation, faulting and hydrofracturing constrain fluid flow, the location of seafloor gas seeps and associated ecological communities. Using high resolution models based on 2D seismic data to investigate the subsurface processes of faulting and fluid flow we seek to further our understanding of how such processes interact. Furthermore, we compare our observations at this location to other sites across the southern Hikurangi Margin with the aim of understanding how these processes have evolved as deformation continues.

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GeoCamp and Tūhura Papatūānuku – engaging students with hands-on science outreach

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8A: Geo-Teaching & Practice, C1, November 25, 2020, 11:00 AM - 1:00 PM

Since 2012 GNS Science has been running GeoCamp, a field-based learning experience that opens up the world of science for local years seven to nine school students and teachers. To date, eight of these events have been held across Te Ika-a-Māui/North Island. The aim of GeoCamp is to give school children the opportunity to learn from expert scientists, demystify science, create enthusiasm and undertake hands-on minds-on learning.

In 2020, funding received from Unlocking Curious Minds allowed us to further develop the idea of GeoCamp through three marae-based, residential events – Tūhura Papatūānuku. Through Tūhura Papatūānuku, we aim to incorporate Mātauranga Māori as a central element. This means the schedule and curriculum is co-designed with the local educators and hapū who are hosting each camp, and delivery of the content is shared. We hope to create a space where the entire UCM team (GNS Science researchers and Māori educators) are able to deliver the concepts and material they believe is important toward the goal of helping the students develop an enthusiasm for science that is relevant to their context.

GeoCamp is not aimed exclusively at students that have expressed an interest in science. Many of them are students that have struggled in a conventional classroom setting, with GeoCamp providing the opportunity to try a different approach of hands-on learning. Across these events we have gathered feedback from educators and students with the aim of developing the programme over time. One of the key aims is to help the educators gain new skills and develop lesson plans that they can then take back to their schools, thereby reaching a broader scope of students and creating an ongoing legacy beyond the event itself. Here we discuss past successes, what we could do differently, and what we aim to do moving forward.

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Preliminary Kinematic Model of New Zealand from Fault Slip Rates

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

We use fault slip rate observations to construct a kinematic model of New Zealand that represents deformation averaged over several seismic cycles. We use a non-linear regression method to solve for a velocity field that is consistent with slip rate observations and relative plate motions. Away from faults, our method results in velocities that minimise strain rate magnitudes (viscous thin sheet approximation). Preliminary results provide a kinematic velocity model for the New Zealand plate boundary zone that fits fault observations and plate motions.

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Significant variations in late Holocene South Pacific gyre strength

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6C: Climate, C3, November 24, 2020, 2:30 PM - 4:30 PM

The Pacific Ocean subtropical gyres significantly influence the Earth's climate and ecosystems. Over the last decades, an increase in subtropical South Pacific Gyre (SPG) circulation has led to warming in the southwest Pacific up to 4x the global average. Are these changes anomalous or part of a natural cycle? Determining this requires long-term records of baseline ocean dynamics in the southwest Pacific. Unfortunately, SPG observations are sparse and instrumental records only span a few decades. Here we reconstruct 3000 years of SPG circulation dynamics at decadal resolution by measuring marine radiocarbon reservoir age deviations (ΔR) in New Zealand black corals. We find that over the last millennium, century-scale ΔR variations around New Zealand are inversely correlated with reconstructions of the Southern Annular Mode (SAM) ($r = -0.48$, $p < 0.01$) from the eastern Pacific. We also observe a depression in mean ΔR between 2000-3000 year BP.

We propose that the subtropical SPG experiences modes of natural variability on multi- century and millennium timescales. Multi-century ΔR oscillations may represent varying ocean circulation strength and mixed-layer depth driven by changing westerly winds. This is supported by a correspondence between ΔR/SAM variations and reconstructions of New Zealand's synoptic meteorology and temperature over the last millennium. Our record also reveals a baseline shift in subtropical SPG mean ΔR that begins ca. 1900BP. This observation mirrors a late Holocene SPG ΔR record showing a change in circulation over the 1900-3000BP interval, possibly forced by a shift in the mean state of the El Niño Southern Oscillation (ENSO).

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When the wiggles match: Effects of old carbon contamination on radiocarbon ages for the Changbaishan Millennium eruption, with implications for the Taupo First Millennium Eruption

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Controversy exists on whether wiggle match radiocarbon age series samples can be contaminated by sufficient magmatic carbon to affect dating of prehistoric eruptions. The Changbaishan Millennium eruption is an ideal candidate by which to test an assumption of zero contamination: the eruption is dated independently by dendrochronological anchoring on the 774/775 CE Solar Particle Event (SPE), and multiple wiggle match age series have been measured from different positions around the edifice. Wiggle match fits at different constant levels of geologic carbon contamination can therefore be compared to the SPE-based year. We analysed published wiggle match radiocarbon age series for seven trees, employing the OxCal4.4 D-Sequence option and the IntCal20 calibration curve to generate Oxford Agreement Indices and eruption date probability distributions for 0-5% contamination. Conventional radiocarbon ages were adjusted using the contamination variable phi (ϕ) in equation $\Delta t = -\tau \ln(1-\phi)$, where Δt is the difference in age at that level of contamination. Published wiggle matches neglect ϕ. None of the series had a best fit at ϕ = 0%. Only one tree yielded a single fit, at ϕ = 0.25%, with a highest probability for an eruption at 943 CE, 3 years earlier than the SPE-based date, with no systematic regional 14C offset. The others yielded second significant fits at dates inconsistent with the SPE date. A similar analysis of the Taupo First Millennium eruption wiggle match, using the SHCal20 curve, yielded two significant eruption dates, at 236 ± 4 CE (ϕ = 0.1%, 1 low AI age), and, with higher agreement indices, at 542 ± 3 CE (ϕ = 3.25%, 1 low AI age). The first match date is consistent with terrestrial near-source radiocarbon dates (potentially subject to magmatic carbon contamination), whereas the later date agrees with the marine reservoir radiocarbon date for the eruption reported elsewhere.

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Unlocking centuries worth of surface UV-B radiation history hidden in pollen

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

UV-B radiation is harmful to humans and the biosphere. Since the discovery of the Antarctic Ozone Hole, we have been very aware of how the intensity of UV-B radiation reaching the Earth's surface can change on short (annual to 10-yearly) timescales, especially here in New Zealand. But how has UV-B flux changed in the more distant past? Answering this is crucial for predicting how UV-B flux might change in the future. Recent work in the Northern Hemisphere has shown that UV-B absorbing compounds (UACs) in pollen cell walls can act as a reliable proxy for relative changes in UV-B flux reaching Earth's surface. This poster presentation documents how we will apply this UAC proxy from pollen preserved in two existing lake sediment records: one from New Zealand (Lake Ohau, South Island) and one from Turkey (Nar Gölü). These two lake cores are annually layered with excellent age control over the last 1500 years in particular. Nar Gölü has already yielded a low-resolution UAC record over the last 650 years. Our preliminary data from Lake Ohau samples is indicative of a trend towards increasing UAC/UV-B levels over the past 70 years, which we interpret as a response to changes in the UV-B climate including reduced ozone driven by anthropogenic chlorofluorocarbon emissions.

This ability to examine UV-B flux over the pre-instrumental timescale and across the hemispheres will allow us to begin addressing a range of as yet unanswered research questions concerned with atmospheric transmission of UV-B and ozone levels, for example does UV-B flux vary through the peaks and troughs of the solar cycles in the way that modelling predicts? This is a significant question, not only because changes in UV flux overall have major implications for human health and the biosphere, but also because UV radiation may affect regional climate change.

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Trace metal partitioning in cave (and cave-analogue) carbonate precipitates – towards a quantitative hydrological proxy in stalagmites

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8C: Geochemistry, C3, November 25, 2020, 11:00 AM - 1:00 PM

Speleothems (secondary cave carbonate deposits) are particularly valuable for studying past climates over a range of temporal and spatial scales, given their mostly continuous growth and exceptional viability for radiometric dating. However, the interpretation of many speleothem-based palaeoenvironmental proxies (e.g., stable isotope ratios $\delta^{18}O$ and $\delta^{13}C$) in terms of particular environmental or climatic controls remains challenging, and is typically limited to qualitative accounts of past environmental conditions and dynamics.

In this study, we develop a novel class of quantitative hydrological proxies by exploring the kinetic behaviour of a suite of first-row transition metals (e.g., Ni, Cu, Co) found in stalagmites. The transport of these elements from the surface to the cave is largely governed by the binding to natural organic matter (NOM) present in percolating waters. The rate of dissociation of such metal-NOM complexes at the dripwater-stalagmite interface has recently been proposed to determine the availability of these elements for the incorporation into precipitates[1]. The link between NOM-complex dissociation and metal availability for deposition presents an opportunity to quantitatively relate respective carbonate metal concentrations to the time available for complexes to disintegrate and release metals within the thin water films on stalagmite surfaces. The water residence time may in turn be modelled as a function of the drip rate at the time of the carbonate deposition.

Here, we present preliminary analyses of modern carbonates collected from a monitored natural cave setting, as well as from controlled cave-analogue experimental setups. Our results provide important contributions towards establishing a quantifiable drip rate control on kinetically-limited elements in stalagmites by demonstrating contrasting partitioning behaviours of different elements, and emphasising the critical role of organic ligands in the supply of certain metals to speleothems.

[1]Hartland, A., Zitoun, R. (2018) Transition metal availability to speleothems controlled by organic binding ligands. Geochem. Persp. Let. 8, 22–25.

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TephraNZ: a major and trace element reference dataset for prominent Quaternary rhyolitic tephras in New Zealand

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Although tephra-derived glass-shard analyses have been undertaken in New Zealand for around four decades, our study is the first to systematically develop a comprehensive, open access, reference dataset of glass shard geochemistry. These data will provide an important open access, reference tool for future studies to identify and correlate tephra deposits within New Zealand and beyond - we present the foundation dataset for “TephraNZ”.

Prominent, rhyolitic, tephra deposits from the Quaternary were identified, with sample collection targeting original type sites or locations where the tephra’s identification is unequivocally known based on independent dating techniques. Glass shards were extracted and major and trace element geochemical compositions were determined. The dataset contains samples characterising 45 eruptive episodes from Kaharoa (636 ? 12 cal. yrs BP) to the Hikuroa Pumice member (2.0 ? 0.6 Ma) from ≥6 caldera sources.

Using statistical analysis and geochemical investigation, we show that geochemical compositions of glass shards from individual eruptions are commonly distinguished by major elements, but not always. For those tephras with similar glass major-element signatures, some can be further distinguished using trace elements and trace element ratios.

Geochemistry cannot be used solely to distinguish between glass shards from tephra groups, however, other characteristics can be used to separate and distinguish all of these except Poronui and Karapiti. Tephra sourced from Taupō Volcanic Centre and Mangakino Volcanic Centre can be separated using bivariate plots of SiO_2/K_2O vs. Na_2O+K_2O. Glass shards from tephras derived from Kapenga Volcanic Centre, Rotorua Volcanic Centre and Whakamaru Volcanic Centre have similar major- and trace-element geochemical compositions to those from the Mangakino Volcanic Centre, but can overlap with Taupō Volcanic Centre and Okataina Volcanic Centre sourced tephra.

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Holocene vertical motions of the Kaikōura Coast

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The 2016 Kaikōura earthquake caused highly variable, multi-metre uplift and subsidence of a ~110 km stretch of coastline. The ages and height distributions of uplifted coastlines are often used to infer the timings and source parameters of past earthquakes. Historically, it has been difficult to test these palaeoseismic inferences, but such a test is possible following the 2016 earthquake.

We map and date Holocene marine terraces along the Kaikōura coast, comparing the magnitudes of 2016 and older uplift and assessing the contribution of faults that ruptured in 2016 to longer-term uplift. We find that: (1) slip on crustal faults can explain all Holocene uplift of the Kaikōura coast without any significant contribution from the Hikurangi subduction interface; and (2) the magnitude of vertical motions in past earthquakes is generally similar to that of 2016 uplift. These results suggest that for the Kaikōura region, palaeoseismic inferences are generally consistent with observed coseismic deformation. One major exception is the Parikawa section of coast, which subsided in 2016 but is uplifted in the longer term, probably through slip on an offshore crustal fault.

Earthquake ages are clustered in time and consistent with (although not indicative of) past multi-fault rupture. However, it is hard to assess the degree of clustering because of difficulties correlating onshore and coastal palaeoearthquakes.

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Could the 1929 Ms7.8 Buller (Murchison) Earthquake have been a multi-fault rupture?

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The 1929 Ms7.8 Buller (Murchison) Earthquake is one of the largest historical earthquakes recorded in New Zealand, with reports of shaking felt over much of the country. The recent Kaikōura, Darfield and Edgecumbe earthquakes all ruptured multiple faults and here we ask the question, was the 1929 Ms7.8 Buller (Murchison) Earthquake also a multi-fault rupture? Our study includes a re-examination of the literature for the 1929 Buller event, a collation of the available spatial data and new field measurements from key sites of surface ruptures. The mapped surface ruptures were primarily on the White Creek Fault which produced reverse sinistral displacement of up to ~5 m (Berryman, 1980). The distribution of landslides and liquefaction, felt intensity reports and the earthquake magnitude are all consistent with a total rupture length of >100 km, significantly greater than the ~8 km mapped for the White Creek Fault (Henderson, 1937). We suggest that in addition to the White Creek Fault the earthquake may have ruptured parts of the Kongahu and Glasgow faults north and west of the White Creek Fault. The 1929 earthquake also produced three mapped surface ruptures 3-5 km in length across the Buller River Valley up to 15 km east of the White Creek Fault (Henderson, 1937). These smaller fault traces may partly reflect off-fault deformation associated with bedding-plane slip and folding. The answer to our question is yes. The available data may indicate that the earthquake ruptured faults distributed across ~50 km of the North Westland fold and thrust belt. The proposed rupture pattern supports the view that multi-fault ruptures are common in New Zealand and that they can occur in low-strain areas distal from the Hikurangi subduction system.

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The 2019 Taupō seismic swarms reveal a stratified and active magma reservoir

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Taupō volcano hosted Earth's most recent supereruption (~25.4 ka) and at least 28 smaller eruptions have occurred since. Geochemical investigations of erupted magmas suggests that a substantial magma reservoir, capable of producing significant eruptible volumes of magma at geologically short notice, exists beneath the present-day composite caldera that is now concealed beneath Lake Taupō. Taupō thus poses a large potential hazard to New Zealand's population and economy, yet relatively little is known about unrest in the magma system and how it interacts with the extensional tectonics in the area. In 2019, Taupō was unusually seismically active. In September in particular a seismic swarm was initiated by magnitude 5.2 earthquake, the largest that has occurred in the region for at least 35 years. We use a match-filter technique to detect over seven-thousand earthquakes which occurred under Lake Taupō in 2019. Through detailed earthquake locations and moment-tensor analysis we show that the majority of these earthquakes occurred along sub-horizontal planes at depths of ~5, 7.5, and 11 km. These depths are consistent with petrologically-determined compositional and rheological boundaries within a stratified silicic magma reservoir. We suggest that the 2019 Taupō seismic unrest was caused by mafic melt ponding as sills at rheological/compositional boundaries within the predominantly silicic magma reservoir. This unrest then culminated in the September magnitude 5.2 earthquake which had a moment tensor and frequency content suggesting fluid interaction and was at depths consistent with the upper parts of a silicic magma body. Our study highlights the importance of detailed seismic analysis in this highly active magmatic system.

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Ambient Noise Velocity Changes at Whakaari, White Island 2012-2020

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6A: Volcanism, C1, November 24, 2020, 2:30 PM - 4:30 PM

Ambient noise autocorrelations from seismic stations on Whakaari have been shown to changes around past Whakaari eruptions and large regional earthquakes (2013, Yates). I present the autocorrelation velocities from 2012-2020, to reveal velocity changes associated with the December 2019 eruption. Some cross-components show a relatively low velocity in the months preceding the eruption, coinciding with earthquake swarms and increases in measured gas flux around the volcano.

Relative velocity changes are calculated between a "reference" stack and a shorter “current” stack. The Whakaari dataset is used to demonstrate the sensitivity to the choice of reference stacks and test how the choice impacts the observation of velocity changes. This is done with the help of another quality control measure ,the similarity (correlation) between the reference stack and the shorter moving stacks. In addition to indicating possible physical changes at the volcano, the similarity analysis identifies a clear change in one seismometer component during an instrument servicing. The change is not obvious in the velocity results themselves but may contribute to hidden errors.

Stacking station velocity results and different individual station-component pairs is a common practice used to accentuate small velocity changes. However, there are some indications that different component pairs behave differently. We use the Whakaari dataset to investigate what is gained and lost through common station-component stacking practices.

The velocity changes and similarity analysis preceding the December 2019 eruptions will also be compared to alert levels and other parameters known prior to the eruption to explore whether real-time velocity analysis could have value in informing future alert levels or eruption prediction efforts.

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Climate modulation of laminae deposition in Adélie Land, East Antarctica

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6C: Climate, C3, November 24, 2020, 2:30 PM - 4:30 PM

Wind driven currents along Antarctica's coastal margins help regulate the exchange of heat, salt, and nutrients between the marine based ice sheets, continental shelf, and Southern Ocean. In turn, this exchange can affect sea ice conditions, primary productivity, and bottom water formation. Climate variability of wind driven currents may affect these processes at centennial to millennial timescales; however, characterising long term variability is difficult as observational data cannot resolve these timescales. Here, we present a new Holocene climate record from Integrated Ocean Drilling Program (IODP) sediment core U1357B in the Adélie Basin, East Antarctica, which consists of contrasting light and dark centimetre scale laminations through the entire 170 m of core. In this region, light laminations are interpreted to reflect changes in biological sedimentation as sea ice retreats, whereas dark laminations represent open ocean conditions. Using X-ray Computed Tomography, and supported by grain size distributions, XRF data, and other physical core properties, we quantify these laminations, and characterise their occurrence by changing environmental conditions. We investigate how grain size variations can be used to assess changes in wind-driven currents, and how these changes may influence dark and light laminae deposition through the Holocene. The result is a centennially resolved coastal current reconstruction for the Holocene along the Adélie Land Margin.

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What do undergraduate students gain from field experiences? A practical guide to assessment and evaluation

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9A: Geo-Teaching & Practice, C1, November 25, 2020, 2:30 PM - 3:30 PM

Undergraduate field experiences (UFEs) are often transformative for geoscience students, developing content knowledge, transferable skills, and scientific identity. Teaching in and about the field is a critical skill for the geoscience educator, given its prominence in geoscience programs. UFEs vary considerably in design; for example, classroom-based courses with single day trips, residential field camps that run weeks or months, or virtual environments that may be accessed repeatedly. Some focus more on field skills and data collection, others more heavily involve independent research. Despite the significance and complexity of UFEs, student outcomes have not widely documented. Furthermore, the differences between UFEs makes generalising documented outcomes difficult.

In response to calls from the UFE community, we present an approach to assessing, evaluating, and researching UFEs, aimed at field lecturers and program convenors who are interested in investigating the impact of their field experiences. This approach is grounded in educational theory, evidence-based assessment practices, and recent work in UFE outcomes. It was developed and refined through application to varied UFE designs and investigations. Our logic model assists the educator in considering four major components:

1. Outcomes – How are these aligned with design? Which are salient to the investigation?
2. Context – How is the UFE structured? Who are the students?
3. Approach – Why is the assessment being conducted? What type(s) of data are needed?
4. Next Steps – How can the findings be used to refine field design and inform the wider community?

This logic model for UFE assessment is intended as a guide, promoting research-informed assessment and reflective practice. It aims to support more comprehensive and aligned assessment of UFEs, enabling thoughtful curriculum design and iteration for the betterment of field education, and hence, student outcomes.

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Internal textural controls on secondary vesiculation of silicic magma

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Volcanic eruptions are driven by gas overpressure generated as volatiles exsolve from an ascending melt. Exsolution of volatiles can drive melt vesiculation; an interplay of bubble nucleation, growth, and coalescence that controls how exsolved gases interact with the melt. Vesiculation requires the melt to be in a state of supersaturation, where the volatiles dissolved in the melt exceed their pressure- and temperature-controlled solubility limits. Several previous studies have investigated how altering pressure, temperature and melt composition affect vesiculation during magma ascent. These aspects are all large-scale and predict how magma bodies will react to perturbations when moving from source-to-vent. Comparatively, little attention has been paid to how small, near surface pressure and temperature fluctuations can cause localized additional vesiculation that can have unpredictable eruptive consequences. Specifically, no study has investigated how pre-existing internal structures, like bubble nuclei, may enhance a melt's ability to undergo late and shallow secondary vesiculation.

Composite vulcanian bombs from the Puyehue-Cordòn Caulle 2011-2012 eruption were selected for this study, because of their internal textural range and evidence for local and variable late-stage vesiculation. Fourier-transform infrared (FTIR) spectroscopy of obsidian chips from within the bombs show low and relatively constant volatile contents (0.05-0.35 wt. % H_2O), suggesting that absolute volatile content had limited effect on secondary vesiculation. Bombs containing obsidian were scanned using X-ray computed tomography (XCT) to determine textures. The rocks were then experimentally heated to ~900°C, above the glass transition temperature, to allow them to become reactive and begin to vesiculate. After heating, the samples were re-scanned by XCT, and compared to observe how pre-existing internal textures affected secondary vesiculation. Preliminary results indicate that in the absence of large volatile supersaturations, significant secondary vesiculation is promoted in regions with high porosities prior to heating, indicating bubble growth is the dominant process instead of bubble nucleation.

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Source properties of moderate-magnitude earthquakes to quantify variations in seismogenic characteristics along the Alpine Fault transitional segments.

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The Alpine Fault is a major active continental transform fault that is late in its typical cycle of large earthquakes: extensive paleoseismic research has revealed that the central section of the Alpine Fault ruptures in M7+ earthquakes every 291±23 years and last ruptured in 1717 AD. The paleoseismic results also reveal that some small-scale segments of the fault, which coincide with pronounced along-strike changes in fault characteristics, act as conditional barriers to rupture. The geometry, seismicity rates and geology of the Alpine Fault change along three principal sections but it is unclear whether source properties (e.g. stress drop, directivity) of near-fault seismicity also vary between those fault segments, and whether these properties can elucidate, or have some influence on the conditional segmentation of the Alpine Fault during large earthquake rupture.

To constrain whether preferred propagation direction and the rupture process influence the conditional segmentation of Alpine Fault earthquakes, we calculate stress drops and directivity of moderate-magnitude earthquakes occurring on and close to the Alpine Fault, using an empirical Green's function (EGF) approach. We use data from dense, temporary seismometer networks, including DWARFS (Dense Westland Arrays Researching Fault Segmentation), a new two-part network designed to constrain seismogenic behaviour near key transitional boundaries on the Alpine Fault. In particular, we focus on the Alpine-Hope-Kelly Fault junction near Inchbonnie, and the Alpine-Puysegur transition south of Haast. Our results investigate the spatial variability of these source properties along the length of the Alpine Fault, focussing on whether earthquakes at the rupture segment boundaries behave differently to those in the middle of previously identified rupture segments.

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Crucial Metals in Exposed Mantle: Ni, Co, Cu & Zn in Zealandia's Ultramafic Rocks

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7C: Minerals, C3, November 25, 2020, 8:30 AM - 10:30 AM

Crucial metals are economic metal resources essential for advanced innovation and are often referred to as ‘critical elements,’ ‘green minerals,’ or ‘clean tech minerals.’ With a growing demand for crucial metal resources for the production of green technology, understanding the source reservoirs and geochemical behaviours of these elements is paramount. This study investigates a select suite of crucial metal elements: Ni, Co, Cu, and Zn as they reside in ultramafic rocks sampled from exposures of Zealandia’s lithospheric mantle.

Our investigation focuses primarily on ophiolitic ultramafic rocks, furthering our understanding of crucial metals within large expanses of mantle exposures that have potential for resource excavation. Ophiolites offer a range of ultramafic lithologies to examine, which in this study includes peridotites (harzburgitic and dunitic species), orthopyroxenites, chromitites, and serpentinites.

We find that whole rock crucial metal budgets report the general relative abundance: Ni > Co > Zn > Cu, with maximum values of Ni = 2800ppm (dunite), Co = 210ppm (chromitite), Zn = 280ppm (chromitite), and Cu = 230ppm (serpentinite). Crucial metals are primarily found in trace sulphide and alloy phases, predominantly occurring within the Ni-Fe-Cu system, but are also found within major silicate and oxide mineral phases. This is particularly true of Ni which resides in olivine phases, making the olivine modal abundance of each lithology a strong control on Ni budget. Analyses such as XFM mapping, LA-ICP-MS spot analyses, and SEM chemical analyses and imaging reports associations between Ni and olivine phases, Co and Zn with spinel phases (with a more direct correlation to Fe concentration), and Cu with OPX phases with high variability in Cu-sulphide occurrences. Serpentinisation strongly remobilises elements with results such as the conversion of Ni sequestered in olivine into sulphide and alloy phases, concentrating Co and Zn in iron exsolution, and producing coarse Cu-sulphides.

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It's not Over When the Shaking Stops: Lessons in Resilience from the Kaikoura Earthquake

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5B: Engineering Geology, C2, November 24, 2020, 11:00 AM - 1:00 PM

The November 2016 Kaikōura earthquake triggered thousands of large landslides and caused severe disruption to the regional transport network in the upper South Island, with State Highway 1 and the Main North Rail Line closed for over 9 months.

Experience from overseas earthquakes, and corroborated by the Kaikōura experience suggests that steep, mountainous hillslopes are significantly more susceptible to slope failure for an extended period of time (many years) following large earthquakes. Large scale slope failures and debris flows in 2017 following ex-Tropical Cyclones Debbie and Cook and 2018, following ex-Tropical Cyclone Gita on the Kaikōura Coast were evidence of this increased susceptibility, and provided valuable lessons on the post-seismic impacts of large earthquakes on transport network performance.

Under the NCTIR project, the resilience of the coastal transport corridor route has been assessed taking into account the engineering geomorphology of the coastal hillslopes with consideration for surface level change observable in LiDAR datasets to assess potential hillslope vulnerability. The hillslope vulnerability in turn was considered in relation to improvements from slope repair and remediation, as well as route realignment to establish response priorities for subsequent hazard events.

The intent of this presentation is to provide some of the experience in regard the post-seismic resilience of the transport, and in particular, the assessment process adopted and the outcomes to enable the asset owners to manage the future outage risks to their networks so that service levels and social and statutory responsibilities could be met.

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Hydrothermal rock alteration as a possible control on eruption dynamics at Whakaari volcano

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6A: Volcanism, C1, November 24, 2020, 2:30 PM - 4:30 PM

At Whakaari, hot groundwater and magmatic fluids circulate through the volcano's structure, constantly changing its physical and chemical properties. But how this hydrothermal alteration affects eruption dynamics and its manifestation in geophysical data used for monitoring is not well understood. Here we experimentally study hydrothermal alteration at Whakaari using variably altered ballistics (lava, tuff, and breccia) and surface outcrops (sulfur flow). We measured the physical and chemical properties (connected porosity and mineral alteration), seismic signatures (P- and S-wave velocity at representative subsurface conditions) and magnetic signatures (magnetic susceptibility and remanent magnetization) of representative samples. Our results show that hydrothermal alteration forms secondary minerals like Alunite, Cristobalite, Tridymite, Anhydrite, Kaolinite, Pyrite, and Opal-A that either precipitate in the connected pore spaces or partially or completely replace the primary mineralogy of the samples. Overall, alteration either creates or destroys fluid pathways by competing processes of dissolution and secondary mineral precipitation. The dominant alteration mechanism differs between sample types. In lava samples, the connected porosity increases and elastic wave velocities decrease with alteration indicating net dissolution. In contrast, in tuffs the connected porosity decreases and elastic wave velocities increase with alteration indicating net precipitation. We confirmed these results independently with back-scattered electron (BSE) imaging showing secondary dissolution pores in lavas and predominant filling of pores with secondary minerals in tuffs. We believe that phreatic eruptions at Whakaari can be triggered when fluid pressure builds up in the subsurface due to restricted fluid movement in highly altered tuff layers. Results from magnetic measurements show that altered lavas can carry higher remanent magnetization than fresh ones, possibly due to thermal effects or grain size reduction during alteration. Our dataset of seismic wave and magnetic signatures of these alteration processes will help calibrate future field-scale geophysical studies to understand and monitor Whakaari's subsurface

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Application of Space Geodesy to Vertical Land Motion in New Zealand

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Sea-level rise is one consequence of Earth's changing climate. Century-long tide gauge records show that global mean sea-level rise reached 11-16 cm during the twentieth century at a mean rate of 1.2 mm/y. Today, the average rate of global mean sea-level rise is higher at ~3 mm/y and is expected to increase in the future. This represents a hazard to low elevation coastal zones worldwide. Yet, before global sea-level projections can be used to characterize future coastal flood hazard at a local scale, the effects of tectonics (and other processes) that drive vertical land motion (VLM) must be considered. VLM can be expressed as the vertical velocity (uplift or subsidence) of the solid surface with respect to the centre of Earth.

In New Zealand, the active tectonics of the Pacific-Australian plate boundary make the characterisation of VLM challenging. Subduction along the Hikurangi margin dominates the spatial and temporal signature of VLM along the North Island's east coast. In the South Island, numerous earthquakes during the last decade have resulted in varying amounts of co- and post-seismic uplift at nearby coastal strips, and which have offset the effects of sea-level rise to varying degrees.

In this study, we use satellite radar interferometry and GNSS to assess VLM in the Christchurch region following the 2016 Mw 5.7 Valentine's Day earthquake. Preliminary data suggest that the coastal strip of New Brighton has been subsiding at a rate of up to 10 mm/y since the earthquake. This geodetic signal suggests that the young sediments that constitute the coastal spit have been destabilised by the earthquake shaking. These data demonstrate the utility of modern space-borne techniques in characterising VLM at coastal cities, and the importance of monitoring the ongoing effects associated with earthquake deformation.

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A data-model comparison of marine primary productivity during the Last Glacial Maximum and the Last Inter-Glacial

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5C: Climate, C3, November 24, 2020, 11:00 AM - 1:00 PM

We present a data-model comparison of marine primary productivity in the Last Glacial Maximum (LGM; 21,000 bp) and the Last Inter-Glacial (LIG or marine isotope stage 5e; 127,000 bp), focusing on the Southwest Pacific and the Southern Ocean. These two time slices represent a colder-than-present (LGM) and a warmer-than-present (LIG) climate, allowing us to evaluate the model's ability to represent contrasting climates. Equilibrium model simulations of the LGM and LIG were performed with the intermediate-complexity UVic ESCM v2.9, modified to include a calcifying plankton functional type and a prognostic iron cycle. Proxies for primary productivity were compiled from existing marine sediment core records collected in the Southern Hemisphere. We compare the proxy data to the anomaly from a pre-industrial control simulation, focusing on the relative change in carbon export and primary productivity (both abundance and distribution). Key metrics include sea surface temperature, plankton biomass and net primary productivity (NPP), and sediment CaCO3 content.

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Quantifying the magmatic volatile (F, Cl, S) budget of arc magmas with apatite inclusions in zircon

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Porphyry deposits are an important global source of copper, gold and molybdenum- resources essential to meet growing demand for renewable energy technologies and electric vehicles. While porphyry Cu ± Au ± Mo deposits are valuable exploration targets, it remains difficult to explain why some arc-related igneous belts host large and extremely metal rich porphyry deposits while bracketing igneous intrusions are weakly mineralised or barren. Magmatic volatiles facilitate ore metal transport and concentration into a highly mobile, exsolved volatile phase, and therefore the volatile budgets of arc-related magmas are important to their fertility for ore formation. The abundance and behaviour of magmatic volatile species such as H_2O, H_2S, SO_2 CO_2, and HCl are difficult to quantify. An emerging tool for constraining magmatic volatile activity is the common accessory mineral apatite, which incorporates numerous volatile species into its crystal lattice (Cl, F, S, H_2O, CO_2). This study trials a novel approach to the collection of magmatic volatile data- the analysis of apatite inclusions trapped within zircon. In this state, apatite is protected from late fluid/heating events and is accompanied by a wealth of geochemical information provided by the host zircon. In this study, we apply mineral-melt calculations to apatite inclusions in zircons to quantify and compare the volatile budget of mineralised and unmineralised arc-related magmas in Eastern Australia, employing zircon samples known to be rich in apatite inclusions. Samples have been sourced from the Cadia, Copper Hill and Cargo Cu-Au porphyry systems of the Macquarie Arc and the unmineralised Jindabyne, Why Worry and Cobargo I-type granitic suites in the eastern Lachlan Orogen.

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Understanding composite volcano architecture through hydrothermal alteration mapping – A case study for Mt Ruapehu, New Zealand

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7A: Volcanism, C1, November 25, 2020, 8:30 AM - 10:30 AM

Composite volcanoes can progressively weaken through hydrothermal alteration, which may lead to volcano collapse, forming far-reaching debris avalanches. Hydrothermal alteration is a leading cause of volcano collapse hazards. Therefore, a robust model and understanding of hydrothermal alteration within a volcanic edifice is important to improve hazard assessment efforts. This study aims to investigate the type and extent of hydrothermal alteration on Mt Ruapehu, New Zealand, using a combination of mineralogical, hyperspectral imaging and aero-magnetic study.
Mt Ruapehu shows surface weathering processing, forming goethite, hematite and phyllosilicate assemblages. Typical hydrothermally altered rock show acid sulfate alteration assemblages, including phyllosilicate, Fe- oxides and sulfates, pyrite, jarosite, alunite, gypsum anhydrite and native sulphur. The surface distribution of such minerals is limited to only ca. 2.6 km2, which was mapped by airborne hyperspectral imaging. This is partially due to the extensive volcaniclastic cover and glaciers on the upper summit region. The surface alteration mapped by hyperspectral remote sensing is linked to the deep-seated (≤500 m) alteration by aero-magnetic inversion modelling. The aero-magnetic data maps the 3D distribution of demagnetized rocks. At Mt Ruapehu, the decrease of magnetic susceptibility can be linked to dissolution of (Ti-)magnetite dissolution as the hydrothermal alteration persist, as well as deposition of brecciated horizons between lava flows and intercalated glacial till and volcaniclastics.
Mt Ruapehu shows examples of multiple hydrothermal systems over its evolution in the last 250 ky. Hydrothermal alteration shows distinct spatial migration over time, and associated mineral overprinting due to surface weathering (e.g. dissolution of meta-stable mineral phases). The aero-magnetic data used in conjunction with previous magnetotellurics data, hyperspectral and hydrothermal mineral mapping, enabled a simplified model to be constructed to capture the hydrothermal processes on Mt Ruapehu, aiding future studies on delineating area prone to mass movements and collapses.

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Reprocessing and Reinterpretation of the 1960 Gravity Survey in the Wright Valley, Antarctica and Implications for Mantle Recycling Processes

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The principal goal of the project is to collect and process new gravity data from the Wright Valley, within the Transantarctic Mountains (TAM), Antarctica. The new gravity measurements were collected along several transects in Lower Wright Valley during the 2018-2019 field season. These new measurements, along with revised, previously collected gravity data (Bull, 1960), are used to calculate the Bouguer gravity anomaly across the edge of the TAM front, at the the Ross Sea coast. Existing gravity data from Bull (1960) were reduced to Bouguer anomalies; however, no 2-D model of structure at depth was constructed from these data. Using gravity modelling software, a 2-D numerical gravity model of crustal thickness and density variations is constructed, with a focus on the tectonic setting of the East/West Antarctica transition. Existing seismic tomography and receiver function data give estimates for crustal thickness and these are used to constrain the gravity model. The 2-D gravity model is then used to present a geologically sensible interpretation for the rift shoulder or uplift of the flank of the rift margin of the TAM front. These merged data and the resulting numerical model provide a test case for the cause of the Bouguer gravity anomaly and mechanism of uplift of the TAM. For example, does the TAM have a crustal root or is it rift shoulder uplift with crustal flexure associated with lateral changes in mantle density? The answer to this question has implications for the mechanism of uplift, such as the possibility of lithospheric delamination or detachment of the mantle lid.

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Landscape evolution in ignimbrite terrains: a study of the Mamaku plateau in the Taupō Volcanic Zone, New Zealand

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The landscape of the central North Island has been shaped by volcanic processes, in particular the deposition of ignimbrites. Ignimbrites are formed by rapid deposition of pyroclastic material via pyroclastic flows, modifying the underlying landscape by filling in stream and river valleys. The subsequent geometry of ignimbrites, and the variability in post-emplacement processes (i.e. welding, vapor phase alteration, and quartz silicification) mean that ignimbrites do not erode evenly. Here, we present new geomorphic data as part of a study to unravel the landscape evolution of the ~1,700 km² Mamaku Plateau; the largest non-caldera landform in the central Taupō Volcanic Zone (TVZ). Remarkably, the Mamaku plateau formed during the short-lived central TVZ ignimbrite flare-up between 350 and 240 ka. During this time, there were eight ignimbrite-forming eruptions with a total erupted volume of >3000 km³ magma. The plateau is situated in the western-central TVZ and is mostly comprised of four ignimbrites (Whakamaru, Chimpanzee, Pokai, and Mamaku). These ignimbrites have been previously mapped and are exposed in steeply incised stream valleys (up to 200 metres deep in places). Combining the previously mapped geology with high resolution LiDAR digital elevation data, we created stream profiles that are coded by geologic unit (i.e. ignimbrite formation). In addition, transects (and cross-sections) at ~90° to the stream profiles were created to infer the geology between the modern valleys. From the profiles and cross-sections, we constructed a series of possible models for how the paleo-landsurface of the Mamaku plateau evolved during the ignimbrite flare-up.
Our models could be used by hydrologists to better understand the water resource present in the Mamaku Plateau (i.e. the Te Waihou – Blue Spring provides 60% of New Zealand's bottled water), and by hazard geologists to forecast how the modern landscape of the Mamaku Plateau may respond to a future pyroclastic flow(s).

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The December 9, 2019 eruption of Whakaari/White Island

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6A: Volcanism, C1, November 24, 2020, 2:30 PM - 4:30 PM

Whakaari/White Island erupted at 14:11 on December 9, 2019. Recorded by a network of four cameras, two seismometers and acoustic arrays, and two GPS stations, the eruption is uniquely captured in the near field. Based largely on geophysical data and camera footage, the eruption involved ~12 discrete explosions from a largely stable vent area, as dense jets that were ejected sub-vertically. The intensity of these jets increased over a period of ~ 45 s to a peak height of ~650 metres above vent. Steam separated from the dense jets to form a plume that buoyantly rose to over 3 km above sea level. Each dense jet collapsed back towards the vent and eventually initiated the outflow of a pyroclastic density current that flowed up and out of the inner crater basin and along the main crater floor. This density current traversed the crater floor, fed by successive jet collapse, at a velocity of ~ 15 m/s until it slowed towards the eastern bays. Similar to the April 2016 eruption, the density current flowed up much of the crater walls and in parts, overtopped the outer crater walls.

While the eruption lasted less than 5 minutes, the impacts have been significant. With 21 fatalities and a further ~24 injured, this is New Zealand's second worst volcanic eruption disaster after the 1886 eruption of Tarawera.

While further analysis of the eruption deposits is required to fully understand the driving forces of this eruption, there is a lot to learn about these short duration events that occur during fluctuating unrest.

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Whakaari/White Island: a review of New Zealand's most active volcano

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6A: Volcanism, C1, November 24, 2020, 2:30 PM - 4:30 PM

Whakaari/White Island is New Zealand's most frequently active volcano with a rich observational history that extends to early Maori settlement in Bay of Plenty and from early European explorers. Documented landings since 1826 record a highly active volcano with variable fumarolic activity, eruptive activity, changing vent locations, and a crater lake that fluctuated over short time intervals.

Unrest and eruptive activity was particularly witnessed in a series of scientific expeditions in late-1960's through into the 1976-2000 eruption episode. These visits spawned the start of volcano monitoring at Whakaari that tested a range of methods (geodesy, geochemistry, seismology, geology) for identifying relatively shallow magmatic and hydrothermal processes. Since that highly active eruption period, combined with new monitoring methods and targeted studies, details of the geological history, magmatic-hydrothermal system, and evolution of Whakaari have been derived. The results of this work sheds new light on the geology and into the processes driving magmatic and phreatic eruptions that can be applied globally. Our review synthesises the range of data, providing a conceptual model of Whakaari. Lastly, we revise the extent of the Whakaari edifice based on new bathymetric mapping to a quasi-circular structure that is ~5 to 6 km diameter.

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A foraminiferal sea-level reconstruction from Pauatahanui Inlet, southern North Island, New Zealand

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Vertical land movement associated with interseismic subsidence and slow-slip events pose a major complicating factor when understanding how sea-level rise is likely to affect New Zealand's capital city of Wellington. To understand how these factors have affected sea level in the long-term, and thereby gain geological context for these movements, the nearest undisturbed salt marsh (Pauatahanui Inlet) was surface sampled and cored. These samples were used to assess the relationship between species of foraminifera (a group of testate protists) and elevation, then apply these relationships down-core to calculate past sea level. The nearest continuous GPS station (Paekakariki Hill) displays 1.7±0.35 mm/yr subsidence since its installation in the year 2000 (Tenzer and Fadil, 2016). However, according to a variety of transfer functions (statistical techniques which relate foraminiferal assemblage to elevation), our sediment core data indicate that, since the 1855 earthquake (which leaves a very distinct signature in the record), relative sea level has risen at Pauatahanui by ~1.4 to 1.6 mm/yr. This is less than what would be expected from subsidence alone, yet also must incorporate a significant signal from anthropogenic sea-level rise. We therefore interpret that the slow subsidence in the cGPS record likely indicates a short-term signal which, over the course of the past century, has been counteracted by events such as the slow-slip associated with the Kapiti Coast source region. This, combined with the lower than expected rates of sea-level rise at the Wellington tide gauge from nearby cGPS stations, suggests that that it is unwise to base local sea level projections on the observed recent net subsidence alone without factoring in the long-term effect of slow-slip and co-seismic uplift.

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Heat and mass transport in the deep TVZ

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9B: Active Tectonics, C2, November 25, 2020, 2:30 PM - 3:30 PM

There is currently no satisfactory numerical model of the heat and water transport through the crust to the surface in high-heat flow regions of the Taupo Volcanic Zone which is consistent with the current geophysical understanding of the region. Here we present early results from numerical models using an in-house code which aims to do this.
Our model consists of a 2-D across-rift section 50 km wide by 15 km deep. The upper 1.5 km is modelled as high-permeability volcanic deposits with a depth-dependent increase from silicic to mafic rock composition in the basement material below. At the base there is a 20 km-wide heat source with a heat flux of either 500 or 900 mW/m2.
Some initial conclusions are:

- A constant permeability throughout the basement cannot explain heat and mass transport to the surface in a way that is consistent with geophysics. To do this, a modification of the bulk permeability-depth relationship proposed by Manning & Ingebritsen (1999) is used.
- Shallow permeabilities of ~ 5x10-14 m2 with a vertical:horizontal ratio of ~0.2 are required for high-temperature geothermal systems to form, and for vigorous convection to occur. For the basement, permeabilities vary from ~10-13 m2 to ~10-18 m2 at 15 km depth with a horizontal:vertical ratio of 3.
- The models predict a brittle-ductile transition at depths of 6-8 km with the above ranges of permeability and heat sources.
- A two-component basement that transitions gradually from silicic to more mafic composition with increasing depth, and with an accompanying rise in solidus temperature, produces a complex distribution of melt compared to that in a single component basement. We find a several km-thick halo of partial rhyolite melts extending from 15 km to 8-10 km depth and, for higher basal heat fluxes, an additional deeper region of basaltic melt.

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Early lichen colonization on earthquake-induced rockfalls: implications for lichenometry and its role in paleoseismic studies

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Lichenometry has been employed as a geochronological dating technique for estimating the exposure age of rock surfaces and landforms. It has also been used extensively in paleoseismic studies to estimate the timing and recurrence interval for shaking events. However, despite its perceived successes, lichenometric dating has faced criticism stemming from a lack of understanding surrounding early phase lichen growth characteristics and uncertainties associated with its methodologies. We characterize early phase lichen colonization on exposed Canterbury Earthquake Sequence (CES) rockfall surfaces at Rāpaki Rock (Te Ahi-a-Tamatea) and Castle Rock (Te Tihi-o-Kahukura) in the Port Hills, New Zealand. A range of lithologies, aspects, and roughness characteristics were chosen for 22 CES rockfall surfaces. For each CES surface, the diameter for the five largest lichens of each identified morphology were measured. We identified nine primary lichen morphologies and calculated growth rates and diameter density plots for each. Our results highlight the succession and spatial distribution of early colonizing lichen species on rockfall surfaces of variable composition and roughness characteristics and report variability in growth rates. Crustose lichens displayed the slowest growth rates (0.238-0.703 mm/year) with unimodal diameter density peaks, while the foliose lichen population had higher early phase growth rates (1.034-2.300 mm/year) but high variability in diameter density peaks. Our results suggest that the lag time for complete colonization for many of the observed species is greater than 9 years, indicating that the resolution of lichenometry is less than previously reported. In addition, Structure from Motion (SfM) Photogrammetry was performed on representative rockfall surfaces to create a three-dimensional photomosaic to monitor early phase lichen growth rates. Indirectly calculated growth rates coupled with the SfM dataset of direct growth rates for all identified lichen morphologies on CES rockfall will enhance the understanding of the utility of lichenometry as a dating technique and paleoseismic tool.

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Ground Motion Simulations for Dunedin - Mosgiel Area

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7B: Active Tectonics, C2, November 25, 2020, 8:30 AM - 10:30 AM

The research addresses Dunedin-Mosgiel seismic hazard. We use scenario earthquakes from local active faults and 2D basin modelling to develop ground motion simulations for the two urban areas. The simulations utilise numerical methods and models that explicitly incorporate the physics of the earthquake source and the propagation of seismic waves in the areas of interest. The simulation method used is that of Graves and Pitarka, and the software platform used is the SCEC BBP.

A major part of the research is dedicated to modelling site effects. Based on 1D wave propagation theory the large impedance contrast resulting from shallow soft soils overlying the harder rocks may cause strong amplification of ground motions at high frequencies. Site response analyses are performed with the nonlinear finite element software OpenSees. The dynamic response characteristics of soft layers are simulated by an elastic isotropic plasticity model. The input ground motions are single components developed by deconvolution of ground motion simulations, so they are modelled below the rock-soil interface, and then convolved via nonlinear wave propagation site response analysis within the soil column.

Two profile lines are selected for 2D-based ground motion simulations, which represents a progression from the 1D analyses: The two lines are, namely: the Kettle Park line, which runs east-west across south Dunedin; and the Taieri basin line, which runs northwest-southeast through Mosgiel. The area of Kettle Park has been the focus of previous QuakeCoRE-funded field investigations of site response. The Taieri basin line crosses the deepest fault-controlled sedimentary basin in the greater Dunedin area.

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Filling the gaps in Antarctica's observational records using Gaussian Process Regression

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5C: Climate, C3, November 24, 2020, 11:00 AM - 1:00 PM

Long-term observations from automatic weather stations (AWS) in Antarctica are challenging for many reasons: climatic conditions are harsh, instruments can fail, and repair or maintenance is costly. As a result many records have observational gaps during certain periods and are incomplete. This can be a challenge for modellers who want to compare modelled climate or weather with such sets of observations. Here, we present a way how to fill the gaps in the observational records in a statistical meaningful way. Applying a Gaussian Process Regression on a network of (incomplete) AWS data, we are able to retrieve missing periods in individual observational AWS records that are realistic and rely purely on the statistical properties of the observed AWS network data. Our approach is a computationally efficient way to fill gaps in existing records. Such a complete set of AWS records can help modellers to better tune and compare their models to observations. Likewise, as a side effect, we can use the same technique to test how well an atmosphere model represents the (statistical) relationships of the AWS network data.

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High-resolution lacustrine records of late Holocene climate change from Southern New Zealand

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Dynamic climate phenomena like the El Niño-Southern Oscillation and the Southern Annular Mode produce precipitation and temperature anomalies that directly influence New Zealand's freshwater ecosystems. However, lack of highly resolved paleoclimate records spanning the last few millennia hinders our ability to place observed modern changes in a longer perspective. Here, we present sediment records of climate and environmental change from two South Island alpine lakes that were collected as part of the Lakes380 program to evaluate ecosystem response to past temperature and precipitation change during the late Holocene. Hyperspectral imaging (HSI) of pigments and µ-X-ray fluorescence (XRF) scanning of elemental abundance were applied to two lake sediment cores. In Lake Lockett (Tasman region), interbedded organic and inorganic silt transitions into mm-scale laminated grey silt at ~120 cm depth. Sedimentary transitions are captured by elemental profiles, such as lithogenic (Fe, Ti, K), organic (incoherent-coherent scattering ratio) and biogenic (Si/Ti) elemental proxies. Principal Component Analysis (PCA) was used to identify common geochemical indicators for catchment and in-lake processes that can be linked to temperature and/or precipitation. PCA results reveal that variance is primarily associated with changes in lithogenic contribution, which corresponds closely with HSI clay proxy R570R630. The second principal component (12% variance) consists of variations in Si/Ti and appears similar to downcore variations in a HSI primary production proxy (R660R670). Strong linkages between geochemical and pigment abundance suggest that driving processes controlling sedimentation within Lake Lockett are related to precipitation-driven processes that affect catchment run-off and erosion. In addition, the combined techniques can isolate productivity changes that is likely related to temperature. This study demonstrates the first steps in integrating high-resolution scanning data to reconstruct paleoenvironmental change and we will expand upon these findings by incorporating a chronology and comparing results to an alpine Canterbury lake sediment record.

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Advances in understanding the Alpine Fault through the lens of Berryman (1975) etc.

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9B: Active Tectonics, C2, November 25, 2020, 2:30 PM - 3:30 PM

The plate tectonic revolution put some context to the role of the Alpine Fault as a plate boundary structure through the South Island. However, prior to the mid-1970's there was still very little data to constrain the activity of the Alpine fault in the form of displacements and the timing of past earthquakes. Kelvin Berryman, amongst other workers, was at the forefront of documenting that the Alpine Fault was active and that it was possible through earthquake geology to characterise the questions of how big and how often – the fault could rupture. This review talk presents how the results of reconnaissance and mapping works such as Berryman (1975) and other EDS reports shaped the future of understanding the seismic potential of the Alpine Fault, leading us toward an advanced knowledge of its behaviour. Berryman (1975) plots the course of two reconnaissance field trips along the Alpine Fault and visits now frequently visited and studied sites between the Matakitaki River in the north and Okuru River in the south. Much of this work matured in time for a seminal review paper on the Alpine Fault in 1992. We also look back at some of the reconnaissance work undertaken in northern Fiordland that led to significant advances from the Hokuri Creek and John O'Groats sites. Kelvin's work on the Alpine Fault also stretched to an appreciation of landscape change as a means to understanding the earthquake cycle, leading to advances from alluvial and lacustrine sites, and toward developing Alpine Fault earthquake scenarios.

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Climate signals from Foulden Maar: Temperature, rainfall, elevated atmospheric CO2 and global greening in earliest Miocene Zealandia

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5C: Climate, C3, November 24, 2020, 11:00 AM - 1:00 PM

Foulden Maar is a *Konservat-Lagerstätten* deposit formed in a maar crater lake in Otago. A 183 m drillcore recovered from the site includes 120 m of laminated diatomite which holds a unique, annually-resolved record of paleoclimate for >100,000 years in the earliest Miocene. Due to anaerobic conditions during deposition, Foulden Maar exhibits exceptional preservation of both plant and animal fossils, ranging from original organic molecules to micro- and macroscopic detail of body fossils. This preservation enables detailed analyses of the interaction of the terrestrial ecosystem that surrounded Foulden Maar in the earliest Miocene with the local and global climate system. To reveal the climate at the time we have carried out the following analyses: Climate Leaf Analysis Multivariate Program (CLAMP), nearest living relative (NLR) analysis of the plant taxa, hydrogen isotopes (δD) on lipid biomarkers from Foulden Maar downcore sediments, carbon isotopes ($\delta^{13}C$) on bulk organic material, leaf tissue and lipid biomarkers from downcore sediments and gas-exchange modeling using microscopic leaf architecture. CLAMP and NLR analyses reveal the Lauraceae-dominated rainforest at Foulden to be marginally subtropical, with a mean annual temperature of ~18°C. Additionally, CLAMP and NLR both suggest rainfall levels high enough to sustain rainforest (>1500 mm yr^{-1}), but with the potential for summer moisture deficits. δD and $\delta^{13}C$ analyses of downcore material suggest substantial regional changes in the hydrological cycle, with one excursion suggesting a change in absolute rainfall, forest transpiration, or a drastic change in water source happening over a 20–30 kyr period. At the same interval, $\delta^{13}C$ and gas-exchange modeling suggests a major perturbation of the global carbon cycle, potentially increasing from 450 ppm to 550 ppm. This carbon cycle perturbation appears to coincide with the initiation of Antarctic deglaciation out of the Oligocene–Miocene transition.

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Laboratory simulations of rainfall-induced landslide reactivation mechanisms following the 2016 Kaikoura Earthquake

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5B: Engineering Geology, C2, November 24, 2020, 11:00 AM - 1:00 PM

Increases in rainfall-induced landslide activity have been observed in many mountainous environments following large earthquakes. Although this increase in activity is mostly attributed to the reactivation of failed and partially failed slopes that have been weakened by ground shaking, determining their sensitivity to failure in different rainstorms through time remains poorly understood. To date progress in this area has been limited as very few large earthquakes have accurate landslide inventories, samples of landslide materials for laboratory testing and repeat high-resolution monitoring that captures landslide remobilisation during subsequent rainstorm events. The 2016 Mw 7.8 Kaikoura earthquake produced over 25,000 landslides and provides one of the first opportunities to study how and when landslides reactivate in rainstorms following a major earthquake in New Zealand's climate and terrain. This laboratory focused study uses standard triaxial cell apparatus to conduct a suite of specialist's experiments on landslide debris to replicate the stress conditions in landslides and characterise their failure mechanisms in response to different scenarios of pore pressure development. The results will provide new knowledge of the failure mechanisms of failed and partially failed slopes during rainstorms for specific geological units impacted during the Kaikoura earthquake and how these may evolve through time. This will form part of a broader study to better understand the long-term hazard of heightened rainfall-induced landslide activity following the Kaikoura earthquake as well as potential future large earthquakes in New Zealand.

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Te tai pari o Aotearoa - new estimates of future sea level along New Zealand's coastline

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4B: Hazards, C2, November 24, 2020, 8:30 AM - 10:30 AM

Uncertainty regarding Antarctic ice sheet (AIS) response to a warming climate was highlighted as a major scientific challenge when the Intergovernmental Panel on Climate Change released its assessment report in 2013. Efforts that aim to reduce this uncertainty have been a focus of Antarctic research over the past decade. Geological records recovered from the Antarctic margin offer insight into the sensitivity of ice sheets to past climate change. Data gleaned from sedimentary archives of previous episodes of environmental change have been used to develop and test numerical ice sheet models that are now being used to project future response of the AIS. New knowledge regarding AIS behaviour is being integrated into probabilistic frameworks to improve global, regional and local sea level projections. This presentation will provide an overview of research in the NZ SeaRise Programme – Te tai pari o Aotearoa. NZ SeaRise is developing local sea level projections for New Zealand's ~15,000 km-long coastline to include new ice sheet model projections and estimates of vertical land movement. These new projections allow us to better evaluate the impact of sea level rise on our coastal environments and communities so that we may better adapt to inevitable change.

The SWAIS 2C Project - Sensitivity of the West Antarctic Ice Sheet in a Warmer World

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2C: Cryosphere, C3, November 23, 2020, 1:30 PM - 3:30 PM

Antarctic ice sheet dynamics remain the largest uncertainty in projections of future sea level rise. The SWAIS 2C Project is a new international effort that aims to understand past and current drivers and thresholds of WAIS dynamics to improve projections of the rate and size of ice sheet changes under a range of elevated greenhouse gas levels in the atmosphere and associated average global temperature scenarios to and beyond the 2°C target of the Paris Climate Agreement. A primary goal of SWAIS 2C is to acquire geological records of WAIS extent from past intervals of warmth including Quaternary super-interglacials. Previous drilling by the Deep-Sea Drilling Project (DSDP), Ocean Drilling Program (ODP), and recent International Ocean Discovery Program (IODP), MeBO, and ANDRILL recovered stratigraphic records of past ice sheet behaviour across the mid to outer continental shelf. Similarly, the response of WAIS to past warmer-than-present climates has been inferred from far-field globally-integrated records of sea level and ocean δ18O. We will utilize new drilling technology to obtain a sedimentary history of past ice sheet dynamics at two locations (Kamb Ice Stream and Crary Ice Rise) along the Siple Coast in the West Antarctic interior. Geological records from this location have proven difficult to obtain but are critical to better constrain marine ice sheet sensitivity to past and future increases in global mean temperature up to 2°C.

The role of fissure eruptions and their volcanic hazard implication of the Pliocene/Quaternary Arxan-Chaihe Volcanic Field (ACVF), NE China

Dr Boxin Li[1], **Prof Karoly Nemeth[1]**, **Ms Julie Palmer[1]**, **A/Prof Alan Palmer[1]**

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The Arxan-Chaihe Volcanic Field (ACVF) is a monogenetic volcanic field located in Eastern Inner Mongolia, along the Great Xing'an Range in NE China, comprised of approximately 45 vents located along a narrow structurally controlled zone covering an area ~3000 km^2. Scoria cones and tuff rings are the main type of volcanoes together with fissure-aligned lava spatter ramparts and their associated lava flows. The area of Arxan is dominated by large and complex scoria cones that initiated the youngest and largest lava flows invading the paleo-valley of the present day west to east orientated Halaha River. Included in the ACVF, from the west to east, are Heaven Lake, Wusulangzi Lake, Dichi Lake, Moon Lake and Tuofengling Lake. All are scoria cones with either shallow lakes in their crater or explosion craters formed due to magma-water interaction. The vent distribution shows a distinct pattern aligned with the regional geological fault pattern. This is believed to provide strong evidence for fissure-controlled eruptions in the recent past, particularly in the youngest eruption sites at Yanshan and Gaoshan which need to be considered when predicting accurate volcanic eruption scenarios. Fissures in low-lying areas , such as in the Dichi Lake region, can interact with an active groundwater system and unexpectedly form a maar by a single explosive outburst resulting in termination of the fissure aligned lava spattering-dominated eruption. The number of vents and the clear evidence of vents shifting along active fissures suggest large volumes of magma are involved with long eruption duration. Sustained ash fall events are evident at the youngest eruption site (~2000 BP). These eruptions can be violent, in the Strombolian or sub-Plinian range. Indications are that in ACVF long-lived eruptions with complex eruption styles can take place. Such a model needs to be embedded in future eruption scenario descriptions

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Continuing on the Legacy: Marine terrace study at Aramoana, southern Hawke's Bay

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8B: Active Tectonics, C2, November 25, 2020, 11:00 AM - 1:00 PM

Kelvin Berryman has left a huge legacy of using marine terraces along the Hikurangi Margin to understand mechanisms, size and timing of large earthquake on the subduction interface and/or nearshore faults. This included pioneering the use of trenching Holocene marine terraces to obtain high resolution dating, stratigraphy, and surveying of terrace morphology. We have continued this legacy in recent years and here summarise the latest findings from a trench at Aramoana in southern Hawke's Bay.

Aramoana is situated 26 km NE of Porangahau, along a prominent stretch of rocky coastline parallel to the nearshore (~6 km) southern Kairakau Fault. It was selected for study because previous work had identified three (poorly-dated) Holocene marine terraces, it's north of the prominent change in interseismic plate coupling and lies inboard of the Madden Canyon, a key turbidite paleoseismology site.

The ~100 m long trench confirmed the presence of three terraces, with a large step (~4.5 m) between the upper and middle terraces, and smaller steps between the middle and lower (~1.6 m) terraces and the lower terrace and present mean sea level (~1.1 m). Beach deposits dip gently seaward and are overlain by dune sand and colluvium, with no identified tsunami deposits. Thirty eight radiocarbon ages from shells (37) and wood (1) are consistent with some of the previous ages and allow us to refine each terrace ages to within an uncertainty range of 300-400 years. Preliminary comparison with terrace mapping and ages from other sites suggest the upper and middle terrace ages likely match the two terraces at Waimarama and the single Kidnappers terrace, ~40 and~60 km to the north, respectively. This could suggest ruptures of multiple faults in the nearshore Kairakau-Waimarama fault system, or subduction earthquakes. Future work will explore these as well as implications for seismic and tsunami hazard.

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Revised late Quaternary glacial history of North Canterbury, New Zealand using cosmogenic radionuclide dating at Lake Tennyson

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

A new glacial chronology for North Canterbury is forthcoming based on 10Be cosmogenic radionuclide surface exposure dates (SED) produced from greywacke boulders embedded in several prominent moraines at Lake Tennyson. More than ~150 SED samples have been collected for this purpose at that site since 2012. The focus of our initial investigation at Lake Tennyson was to date moraines that demarcate two adjacent ice margin recession sequences. The first sequence is for a glacier that formerly occupied Lake Tennyson and the second sequence is for a smaller glacier in the adjacent Princess Stream catchment. Morphosequence mapping for both moraine suites was assisted using aerial photographs and LIDAR. The Tennyson and Princess moraine sequences show similar mean ages for a large, well-developed landform emplaced at ~18.5ka, and several inboard (younger) smaller moraines dated between ~18.5-17ka. These SED-constrained landforms align with the expression of the last termination that has been established elsewhere in the central Southern Alps. There is also evidence of several glacial landforms older than ~25ka preserved beyond the ~18.5ka Tennyson moraine, which are relatively dated via identification of concentrated Kawakawa Oruanui Tephra in overlying coverbeds. Additional SED samples for these outboard landforms and key inboard landforms have been recently obtained. Supporting evidence from SED ages on boulders perched on the bedrock sill at Princess Bath tarn suggests nearly ice-free conditions existed in the catchment by ~12ka. Forthcoming field campaigns in 2020-2023 will harness the remainder of the dataset to complete the structure of ice recession since the last termination and define late glacial landform sequences in the Tennyson and Princess catchments. In addition, a parallel SED sample collection is underway in the Waiau-Guyon catchments to enhance regional replication.

Climatic signals in chemical weathering and soil production on New Zealand's North Island

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8C: Geochemistry, C3, November 25, 2020, 11:00 AM - 1:00 PM

Weathering transforms rock into soil, liberates nutrients for biota, and influences global carbon cycles over geologic timescales. Understanding the interactions between climate, tectonics, erosion rates, biota, and weathering has been a recent focus of much research, but disentangling these complex relationships remains a challenge. Climate should influence chemical reaction rates, and previous workers have suggested a weathering "speed limit" based on reaction kinetics. Recent work from New Zealand's Southern Alps clearly exceed this speed limit, but the relative importance of climate and tectonic uplift in driving rapid weathering remain unclear. Here I present a new dataset from the Tararua Range of New Zealand's North Island, which experiences similar climate to the Southern Alps but are uplifting more slowly. Erosion and weathering rates are significantly slower in the Tararuas (60-320 and 48-160 t/km^2/yr, respectively) than in the western Southern Alps (230-4330 and 80-2060 t/km^2/yr), suggesting a strong tectonic control on weathering rates overall. The intensity of weathering in the Tararuas is roughly invariant across the landscape, suggesting that weathering keeps pace with uplift and erosion. However, spatial patterns in weathering in saprolite (weathered rock) and soils differ markedly across an altitudinal transect. The balance between soil and saprolite weathering shifts dramatically across the landscape: at low (warm) elevations, saprolite weathering dominates, while at high (cold) elevations weathering occurs almost exclusively in soil. This pattern suggests that climate influences saprolite weathering, even where soil weathering keeps pace with erosion. This work highlights the importance of considering deep saprolite weathering independently from soils, and may explain why soil-focused empirical studies have not observed strong trends in chemical weathering across climate gradients.

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What can borehole seismology tell us about ice anisotropy and englacial temperature in the Ross Ice Shelf?

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The Aotearoa Ross Ice Shelf Drilling Program drilled two hot water drill boreholes through a ~370 m thick central Ross Ice Shelf site in late 2017. This provided a rare opportunity to place both seismic receivers and sources at depth to provide a wide range of raypaths to explore the vertical distribution of anisotropic ice fabrics and temperature inside
an ice shelf.

In the first borehole eight 3-component, 15 Hz seismometers were frozen into the ice at 35 m spacing between depths of 80 m and 325 m. Thermistors that are collocated with the borehole seismometers provide temperature measurements at depth to calibrate the seismic observations. The second borehole, located at a distance of ~560 m along the ice flow direction was used to operate a sparker borehole seismic source that was fired in 10 m spacing between depths of 70 m and 270 m.

Recording of these cross-hole seismic signals on the borehole seismometers allows to study the vertical variation of seismic velocities and attenuation inside the ice shelf and how these are affected by ice temperature.

Seismic anisotropy in the ice shelf has been confirmed by the observation of shear wave splitting from surface shot points. Finite-element modelling of the effects of different anisotropic ice fabrics on synthetic cross-hole traveltimes provides a constraint on the character of ice anisotropy at the study site. Anisotropy is found to be the dominant influence on seismic velocities rather than ice temperature, a finding which is used to to explain seemingly differing velocity observations from different seismic survey geometries.

Through a study of P-wave amplitudes, scattering is shown to be a significant contribution to seismic attenuation in the ice shelf besides temperature-controlled intrinsic attenuation.

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Dissolution of crustal xenoliths at Mount Ngauruhoe as an indicator of magma residence time?

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Crustal xenoliths have been used in numerous ways to constrain the behaviour and characteristics of the plumbing systems beneath volcanoes around the world. Quartz-rich xenoliths are ubiquitous in lava flows of Mount Ngauruhoe in New Zealand and have been utilised in previous studies to constrain the depth of origin and the degree of crustal contamination. Determining magma ascent rate and residence time is particularly important for volcanic hazards assessments. Here we attempt a novel geochemical approach, measuring assimilation and mixing at the xenolith-magma boundary from the 1975 eruption of Mount Ngauruhoe in an attempt to better constrain magmatic residence times.

Thin sections of the contact between crustal xenoliths and basaltic melt were analysed using the field-emission electron microprobe at the University of Auckland. A combination of X-ray mapping and quantitative analysis is used to constrain the amount of assimilation for each of the sampled xenoliths. Textures record a wide range of assimilation, from crisp edges with minimal compositional gradients to completely molten and intermingled. In cases with melting, a compositional zone is defined proximal to the xenolith and we use major element glass compositions to determine an approximate mass balance of mixing between the basalt and more silicic partial melt. In addition, crystal chemistry of groundmass pyroxenes are utilized to assess the role of mixing processes on the localized crystallization history of the magma. Mixing proportions will be used to back calculate the amount of assimilation and compared with constraints of assimilation timing based on pre-existing experiments.

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Vertical mixing approaches to the ice shelf-ocean boundary layer

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Ice shelf-ocean boundary layer represents “the last meters” of the path that heat takes from the open ocean to the ice-ocean interface. Understanding the structure of this layer can help us estimate how quickly ocean heat can be transferred through the boundary layer up and how quickly the ice can ablate. Recent observations from the Ross Ice Shelf cavity show that the ocean structure is different from those that ocean models predict, including in the boundary layer. Moreover, modelling efforts of the boundary show that low mixing in the boundary layer can drastically reduce the overall meltrates in a cavity. Here we present how various approaches to mixing in the ice shelf-ocean boundary layer can produce different vertical profiles of temperature, salinity and velocity, and the associated meltrate feedbacks. Experiments in an idealised ice shelf-ocean ROMS model incorporate turbulent boundary layer mixing scheme change, meltwater distribution schemes, tidal effects and KPP vertical boundary mixing analysis. We also compare the resulting profiles from the experiments to the CTD profiles from the Ross Ice Shelf cavity.

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Barriers and solutions for risk reduction: what does local government want/need from scientists?

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2B: Hazards Symposium, C2, November 23, 2020, 1:30 PM – 3:30 PM

This talk will focus on the local government political and community context within which risk reduction science results and communications are received and assimilated. In the talk I will consider how scientists together with the hazards analysts, policy advisors and planners might together get better cut through in an increasingly fraught local government decision-making context.

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An idea: scientific drilling project "interaction": interaction between life, rifting and caldera tectonics in Okataina

Dr Cecile Massiot[1], Dr Ludmila Adam[2], Dr Edward Bertrand[1], Dr Fabio Caratori Tontini[1], Dr Geoff Kilgour[4], Dr Sarah Milicich[1], Dr Craig Miller[4], Dr Alex Nichols[3], Dr Matthew Stott[3], Dr Guido Ventura[5], Dr Pilar Villamor[1], Dr Paul White[4]

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5A: Volcanism, C1, November 24, 2020, 11:00 AM - 1:00 PM

The Okataina Volcanic Centre (OVC) in Aotearoa, New Zealand is of high cultural significance to Māori. The OVC is also a nested caldera complex, one of two giant active calderas of the Taupō Volcanic Zone (TVZ), ranked as New Zealand's highest threat volcano. The OVC is located within the continental intra-arc Taupō Rift which has rapid extension rates, and hosts numerous hydrothermal manifestations dominantly located on some, but not all, parts of the caldera margins. In-situ, sub-surface observations required to better understand interactions between volcanism, rifting, fluid circulation and the deep biosphere are sparse. We propose the INTERACTION (Interaction between life, rifting and caldera Tectonics in Okataina) scientific drilling to provide rock and fluid samples, downhole measurements and a base for a long-term observatory. Downhole samples and data, and new high-resolution ground-based surveys near the borehole will refine and fill gaps in the extensive geophysical, geological and geochemical datasets collected across the OVC and wider TVZ region since the 1950s.

Scientific drilling at the OVC, coupled with extensive stakeholder engagement will lead to improved resilience to natural hazards and sustainable management of groundwater and geothermal resources. Close collaboration with Māori will achieve both scientific and cultural outcomes. New geothermal concepts (heat source, permeability and recharge), geophysical data acquisition and new technology deployment, will help future geothermal development globally. Altogether, scientific drilling at the OVC will advance our understanding of: (1) drivers to volcanic eruptions, feedbacks between volcanic and seismic events, caldera evolution; (2) large-scale hydrology; and (3) diversity, function, and geological processes that support deep subsurface microbial activity and response to a highly active geosphere. At these early stages of planning, we invite the scientific community to contribute to the concept of this project in the exceptional OVC settings and strengthen linkages with other ongoing research and scientific drilling programmes.

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Microstructure and chemistry of cataclasites in DFDP-1 drillcores from the Alpine Fault Zone, New Zealand

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

We have examined characteristics of fault rocks that were deformed across the brittle-creep transition within the Alpine fault zone. The observations presented confirm the exhuming fault rocks were weakened by retrograde processes at this transition, and that this facilitated focusing of deformation. The Deep Fault Drilling Project (DFDP)-1 collected a whole range of rocks that were deformed across this transition, which were able to be classified into different rock types (Toy et al. 2015; Boulton et al., 2017). I measured chemical compositions of each mineral in a defined set of different materials and types of fault rocks in DFDP-1 drillcores by SEM-EDS improving spatial resolution using lower accelerating voltage which enabled the quantification of the compositions of fine-grained authigenic minerals (< 2µm).

Temperatures estimated from chlorite thermometry and pressures estimated by white mica barometry (T=~160 - 350 ºC and P=~100 - 200 MPa) in DFDP-1 samples show the physical conditions the fault rocks were deformed at during exhumation (Massonne and Schreyer, 1987; Bourdelle and Cathelineau, 2015). The lower T (= ~160 ºC) was derived from ultracataclasite within the PSZ, suggesting the chlorite within it formed at shallow depth. The higher T (= ~350 ºC) was derived from a mylonite sample, and suggests that these were chloritised at greater depth. Chlorite in cataclasites (which intervene between mylonites and ultracataclasites in outcrop) has more variable compositions that indicate T of ~180 - 350 ºC. These estimates, which are consistent with those we can infer from microstructures, suggest repeated cycles of brittle and ductile deformation during exhumation across the temperature range ~180 – 350 ^{o}C.

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How does central government use and promote science in disaster risk reduction?

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1B: Hazards Symposium, C2, November 23, 2020, 11:00 AM – 12:00 PM

Central government plays a significant role in implementing disaster risk reduction initiatives to support New Zealand's resilience to disasters. After a series of natural disaster losses over the last decade, there is renewed impetus for disaster risk reduction initiatives and incentives to appear higher on local and national political agendas, and to see more science and evidence-based policy driving effective and efficient risk management.

Academic and research institutions play a crucial role in setting the foundations for what those initiatives could and should comprise. Now, more than ever, relevant and useful research is needed to drive risk reduction policies and practice. However, the integration of research will always face the same barriers (time, risk appetite, fiscal constraints and political agendas) that may, or may not result in successful policy changes. A scientific evidence base enables better understanding of risk, assessment of options, and informed decision-making and setting of priorities for investment in risk reduction. It also sheds light on the wide range of challenges for government in understanding their role in managing known, and unknown risk. For example, we want more sustainable, carbon friendly buildings, but this doesn't always result in structures resilient to a natural hazard event such as earthquakes and tsunami.

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Tracing Antarctic Cryosphere Origins to Climate And Tectonics: A new IODP Proposal

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2C: Cryosphere, C3, November 23, 2020, 1:30 PM - 3:30 PM

Antarctica's ice sheets profoundly influence the global climate system and carbon cycle by impacting ocean and atmospheric circulation, biogeochemical cycles, and sea level. Large ice sheets developed in Antarctica as the Earth transitioned from the warm, high-CO2 Greenhouse world of the Paleocene and Eocene, into the moderate-CO2 world of the Oligocene to early Miocene. There are currently very few direct records of Eocene-Cretaceous climates at high latitudes in Antarctica, and new records will provide important constraints of the magnitude of polar amplification during greenhouse climates. Several hypotheses currently exist to explain Antarctic glacial onset, including declining atmospheric CO2 and the tectonic opening of the Southern Ocean. It is also generally assumed that initial ice sheet expansion near the Eocene/Oligocene boundary was limited to terrestrial ice sheets in East Antarctica, because ice could not easily expand across a marine-inundated West Antarctica in the moderate-CO2 worlds and warmer climates of the Oligocene. However, a more elevated West Antarctica in the Early Oligocene could hold more terrestrial ice than today, even though the climate was warmer than present. Consequently, the ice sheet evolution of the Ross Sea is hypothesized to be strongly-coupled to the tectonic and subsidence history of West Antarctica, rather than climate forcings alone. The Ross Sea is perfectly situated to obtain new perspectives on the tectonic influences on Antarctica's climatic and ice sheet evolution. It is located within West Antarctic Rift System, which allows for direct assessment of rift timing, but also has formed large sedimentary basins that capture and preserve climatic records at high latitudes in Antarctica drill three continental shelf drill sites in the Ross Sea, which form a longitudinal-transect designed to capture this integrated history of tectonic, climate and glacial influences from both East and West Antarctica.

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Cosmogenic 10Be reconstructions of east coast shore platform development, NZ. Insights into the role of relative sea level.

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Modern rock coastlines around New Zealand preserve little evidence of erosion rates during times of past sea level variability, limiting our predictive power for the effects of modern sea level rise. Shore platforms are vestigial remnants of past sea cliff retreat and are present along much of New Zealand's east coast. However, platform ages and retreat chronologies are rare, leading to ongoing debate as to the roles of cliff erosion and surface downwear in the formation of shore platforms. Recent applications of cosmogenic Beryllium-10 dating of shore platform surfaces in other parts of the world have revealed histories of sea-cliff retreat over Holocene time scales. This presentation describes the results of recent cosmogenic ^{10}Be analysis of two shore platforms in tectonically quiescent Auckland (Okakari Point) and tectonically active Kaikoura, NZ. ^{10}Be concentrations obtained from Okakari Point reveal that sea cliff retreat (backwear) likely initiated when sea level reached a similar level to present day at around 7ka BP, rapidly cutting most of the width of the platform that exists at present. Following this was a much longer period of downwearing of the shore platform surface (and much reduced backwear) as sea level underwent small fluctuations over the late-Holocene. Measured nuclide concentrations from a limestone platform in Kaikoura reveal that tectonic uplift and down wearing processes rather than eustatic sea level change and cliff back wear are responsible for the development of the existing shore platforms along that peninsula during the Holocene. This research raises the possibility that rock coasts respond relatively rapidly to increases in sea level and small ($\geq$ 1m) changes in relative sea level can have major geomorphological impact on the formation of shore platforms. Rising sea levels over the 21st century and beyond may therefore drive significant geomorphic change along the rock coasts of New Zealand.

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A seismic reservoir characterization study of the Kora Stratovolcano, Taranaki Basin

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The study of volcanism in sedimentary sequences has attracted attention since volcanic reservoirs have become targets for hydrocarbon exploration. However, the reservoir properties of volcanic rocks in the subsurface can be difficult to determine due to the complex geometries of geological bodies, extreme heterogeneity of rock properties and unpredictable seismic behavior. Quantitative analysis of seismic reflection data can contribute to the identification of rock types and estimation of petrophysical properties by using seismic inversion techniques combined with rock physics analysis.
We present a reservoir geophysics study to estimate the porosity and permeability of the Miocene Kora stratovolcano, which hosts a sub commercial discovery and is buried by more than 1000m of sedimentary strata in the Taranaki Basin. We propose a rock physics model to link petrophysical and seismic properties using well log information, an inversion of seismic data, and the estimation of petrophysical properties by means of neural network approach. The permeability values have been computed by applying a facies-dependent porosity-permeability relation calibrated using core measurements. The inversion successfully utilized algorithmic integration of all available data including seismic angle stacks, well logs, stacking velocity, and structural interpretation. The extrapolation of permeability and porosity values is performed by a multi-layer neural network approach that uses a non-linear operator to estimate petrophysical properties from acoustic impedance.
The petrophysical 3D models enhanced our ability to predict reservoir quality in the highly heterogeneous architecture of Kora Stratovolcano. By integrating seismic interpretation and seismic inversion, we identified a potential exploratory lead which includes a pyroclastic deposit with high values of porosity and permeability. In addition, the result provides a geologically realistic spatial porosity and permeability distribution which helps to understand the subsurface heterogeneities in the study area

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Initial results from an enhanced seismometer network around Taupō volcano, North Island, New Zealand

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Taupō volcano is the site of Earth's youngest supereruption (Oruanui ~25.5 ka), has erupted 28 times since then, and continues to display signs of unrest. However, little is known about the conditions in the modern-day magma reservoir, and interactions between the magma system and its tectonic rift setting are poorly constrained. We know about past magma reservoirs from studying the eruptive products, but the presence of Lake Taupō means that most crustal-scale geophysical studies have not spanned the volcano. Knowledge of the modern magma system is important in interpreting significant unrest, such as that in 2019, which happens with an approximately decadal reoccurrence.

We use seismological methods to investigate controls on the modern seismicity distribution at Taupō, and to image the geometry and state of the magma reservoir beneath Taupō. Through a co-production approach, we have worked with the local iwi: Ngāti Tūwharetoa, to deploy a new seismometer network (ECLIPSE) around the lake. It is designed to complement the existing GeoNet network, and approximately doubles the number of seismic sites within 20 km of the volcano. This will improve the resolution of imaging, and the accuracy of the seismicity characterisation. The 13 broadband seismometers will remain deployed until December 2021.

We will present earthquake locations from the first 6 months of data from the ECLIPSE network, interpreted in relation to the volcano. Preliminary analysis from 8 stations indicate that S-wave energy is attenuated most for ray paths that pass through the crust under the Oruanui caldera area, which would be expected in the presence of a magma reservoir. Preliminary locations show seismicity down to 12 km depth, consistent with geochemical estimates for the depth of magma generation and storage for past eruptive events. This deeper seismicity may be linked to magmatic activity at Taupō volcano.

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Understanding how Mt Taranaki has responded to edifice collapse through eruption sequences.

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Stratovolcanoes are one of the most hazardous volcanic types on Earth producing a multitude of hazardous phenomena. These unstable edifices are prone to collapse, producing destructive debris avalanches which can cause sudden depressurization within the magma system. Mt. Taranaki between 20-30,000 years ago, underwent extreme geomorphic change resulting in a long-lived period of eruptive activity in relation to its two largest edifice collapses and debris avalanches (DA) the Ngaere Formation (5.58 km3) and Pungarehu Formation (7 km3). The Ngaere DA is deposited to the south east of the current massif and the Poto Formation or tephra sequence depicts a time of immense activity with at least 15 eruptive units being produced over a geologically short time period. Above the Poto Tephra, the Paetahi Tephra is a sequence of at least 6 lithologically distinct units that occurred in response to the Pungarehu DA. The relationship between the catastrophic collapses and changing morphology of the massif has influenced the eruptive styles observed from the textural, sedimentologic and lithological, pre and post collapse. The grainsize, density and componentry of the tephra deposits collected from the east of Mt. Taranaki has been applied to understand how these sudden changes to the edifice, magmatic pathways and vent impacts eruption styles and hazards produced from the volcano. XRF analyses of the eruptive units also show how the magmatic system is responding to these changing lithostatic pressure regimes. Combining all this data will hopefully provide a detailed account for how stratovolcanoes are influenced by large edifice collapses.

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Heterogeneous stresses and brittle-ductile deformation during shallow crustal faulting, Hungaroa Fault Zone, Hikurangi Subduction Margin, New Zealand

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6B: Transition Zone, C2, November 24, 2020, 2:30 PM - 4:30 PM

The Hungaroa Fault Zone, an inactive thrust fault along the southern Hikurangi Subduction Margin, accommodated large displacements (~4–10 km) at the onset of subduction in the early Miocene. We apply field geology, microstructural observations and clumped isotope geothermometry to constrain the multiscale slip behavior of this thrust fault.

Within a 40 m-wide high-strain fault core, the calcareous sediments show the following structural features indicative of heterogeneous brittle-ductile deformation: (1) foliation boudinage structures in competent calcareous mudstone with mostly undeformed calcite precipitated in fractures; (2) dark solution seams in isoclinally folded limestone layers formed from calcite dissolution accompanied by passive concentration of phyllosilicates; and (3) multiple generations of strongly deformed shear and extensional calcite veins with formation temperatures ranging from 49.6±13.8°C (HFZ-35.3m, N=18; 95% CI) to 89.0±14.7°C (HFZ-35.5m, N=16; 95% CI). Besides deformation twinning, calcite grains in syntectonic veins have experienced intracrystalline plasticity and interface mobility containing a significant population of low-angle grain boundaries. Tangled and free dislocations are preserved in the center of highly deformed calcite grains, while dislocation walls form in the transition to new, less-strained/strain-free grains. The recrystallized grain size in two calcite veins of 6.0±3.9 µm (HFZ-5.2m_A; N=1339; 1σ) and 7.2±4.2µm (HFZ-19.9m; N=406; 1σ) may indicate high differential stresses (76–134 MPa)—much higher than anticipated for solution-transfer processes in these rocks. Additionally, cathodoluminescence analyses reveal different degree of fluid involvement during calcite vein deformation.

Our results indicate that: (1) stresses are spatiotemporally heterogeneous in crustal fault zones containing mixtures of competent and incompetent minerals; (2) heterogeneous deformation mechanisms, including frictional sliding, pressure solution, and mixed-mode fracturing accommodate slip in shallow crustal fault zones; and (3) brittle fractures play a pivotal role in fault zone deformation by providing fluid pathways that promote low-temperature plasticity of calcite at shallow crustal levels.

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The glacial history of Rocky Top cirque, southeast Fiordland, New Zealand.

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The last glacial termination (LGT) was a sustained period of global warming due to natural causes, during which global air temperatures increased by 4–6°C between ~19-11 ka. The warming pattern was interrupted by cold intervals such as the Antarctic Cold Reversal (ACR), the drivers of which are not yet fully understood. Modern global climate change is an increasingly significant hazard to society, so an understanding of LGT climatic impacts and drivers could provide valuable insight regarding how the future climate system may be affected.

To study the nature of the LGT in the Southern Hemisphere one may turn to the geological archives. New Zealand currently has a temperate climate, where glaciers have high accumulation and ablation rates and are sensitive to small climatic changes, making glacial deposits ideal for investigating climate variability over short and long-term timescales. The study area is Rocky Top cirque, located in the Hunter Mountains of Eastern Fiordland, NZ. This research examines evidence from a set of moraines that are presumed to be formed during the LGT.

The research objectives are to constrain the timing and magnitude of glacier length changes at Rocky Top and to make a quantitative reconstruction of paleoclimate during these changes. The presentation is expected to contain a geomorphic map, equilibrium line altitude reconstruction, and chronology of moraines established by 10Be cosmogenic nuclide surface exposure dating.

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Shallow Conduit and Vent Processes in the 1886 Basaltic Plinian Eruption at Tarawera, New Zealand

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The 1886 eruption of Tarawera, New Zealand, is one of four known examples of basaltic Plinian eruptions. During the climactic phase, high Plinian eruption columns were produced at four vents along an 8-km-long fissure and were simultaneously accompanied by numerous low-intensity phases at separate vents along the same fissure on Mt Tarawera and beyond into Rotomahana.

We present a detailed re-examination of microtextures from proximal and medial suites of clasts. Clasts from the margins of the high Plinian plumes were deposited adjacent to the fissure in beds with widespread dispersal (t1/2 of 100s m), whereas clasts derived from low-intensity eruptions were deposited in beds with localised dispersal (t1/2 10s m). Clast vesicle number densities (VNDs) are similar between all sample locations (in the order of 10^6–10^7 cm^{-3}), vesicle shapes are generally polylobate, and high microlite content (66–89%) is ubiquitous. This evidence suggests that factors related to the external environment (e.g. vent wall collapse) could be more important than previously recognised.

All clasts have a significant secondary bubble population <10μm of different abundances (referred to here as tiny voids) which either represent (1) a late-stage nucleation event, (2) magma contraction during crystallisation, or (3) devitrification of glass due to volatile gases. Investigation into the mechanisms that formed such voids may elucidate shallow conduit processes which contributed to the different eruption styles at Tarawera.
We suggest that for the case of the 1886 Tarawera eruption, VNDs need to be carefully interpreted; for some clasts (particularly the dense clasts), the process which formed the tiny voids which have 'overprinted' the original ascent signature and thus VND is not a proxy for decompression rate.

This research furthers our understanding of a poorly understood and hazardous end-member of basaltic volcanism.

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Palaeomires as ciphers for climate and tectonics: an example from the Early Cretaceous Hailar Basin, Inner Mongolia, China

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

When conducted in tandem, organic petrography and isotopic analyses can be used to interpret regional tectonics and palaeoclimate within a global context. As an example, a sequence of lignite (vitrinite reflectance average = 0.27%) in the Early Cretaceous Yimin Formation, Inner Mongolia, China, was investigated. The study area is within the intracratonic Hailar Basin and was situated at ~ 45ºN palaeolatitude. Globally warm temperatures allowed temperate to tropical vegetation such as ferns, cycads and gymnosperms to form thick, laterally extensive palaeomires within the basin.

Probabilistic assessment indicates that the lower, thick (~40 m) Seam #16 may have accumulated over a time span between 174 (P10) to 481 (P90) thousand years, whereas the thin (~6 m) overlying Seam #16 Upper took between 20 (P10) and 96 (P90) thousand years. Thermal sag processes were active in the basin over this period of time, with subsidence rates balanced to allow enough accommodation space to accumulate thick peat, but not so fast as to induce flooding and burial by clastics. High fossil charcoal (‘inertinite’) indicates that throughout the peat-forming period, fire was an important part of the mire ecology. This is consistent with global high oxygen content and an in-land continental palaeogeographic position with seasonal precipitation. Stable isotopes of carbon indicate periods of high precipitation but also times of significant relative dryness. The palaeoclimatic conditions are likely to be both seasonal as well as longer term, possibly decadal to millennium in scale and would have occurred over the whole region, not just mire specific.

Explorations in the nether: a history of coal seam gas in New Zealand

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3C: Petroleum, C3, November 23, 2020, 4:00 PM - 5:30 PM

Like a rusty lock that won't quite open, coal seam gas (CSG) in New Zealand has eluded our understanding for decades. Since coal mining began in Aotearoa in the 1800s, gas has been seen as mostly a hazard. Indeed, deadly mine explosions are well documented, the most recent, of course, being Pike River in 2010. An influential report by the Ministry of Economic Development in the early 1980s, however, focused on the methane in coal as a resource. From the mid 1980s, Southgas Ltd in the Ohai Coalfield initiated CSG exploration. However, although some wells produced gas, flow rates were low and no commercial production ensued. Few projects occurred until the early 2000s; spurred by the economic success of gas from low rank coals in the USA, multiple companies, some with overseas investors, obtained exploration permits over basins in both the North and South Islands (e.g. Ohai, Greymouth, Buller, Southland, Waiau, Taranaki and Waikato coalfields). Numerous exploration wells were drilled to test gas content, holding capacity and permeability, among other attributes. Data from these wells allowed the most extensive evaluation of reservoir character to date. A limited number of pilot wells were then attempted, but as in the 1980s, these yielded relatively low rates of gas, although water stimulation did have limited success in some trials. The lack of development of CSG in New Zealand is attributable to four factors: 1. Generally low permeability reservoirs, 2. Variable gas saturation in some basins, 3. Small (by CSG standards) and geographically dispersed basins and 4. A relatively small (and not the most competitive) gas market. Unlocking of these resources are still possible, but it will take technical innovation and a market that is flexible and perhaps only locally sited.

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Assessing the likelihood of offshore fresh groundwater in New Zealand

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Offshore aquifer research is an emerging field that is becoming increasingly important as population growth and climate change put pressure on coastal water resources. Offshore drilling in 2009 as part of the International Offshore Drilling Program has shown that there is potential for offshore fresh groundwater (OFG) in New Zealand. The aim of this study is to: (a) systematically screen for coastal aquifers in New Zealand most likely to contain OFG and, (b) document evidence for OFG in New Zealand. The study involves development and application of an OFG likelihood-rating scheme, which provides a simple and transparent first-pass approach to highlighting areas where OFG is more or less likely at the national-scale. We surveyed regional councils responsible for managing coastal aquifers using a questionnaire developed from the OFG likelihood-rating scheme. Survey responses, in combination with national and regional-scale technical documents were then used as data within an application of the rating scheme to all aquifer locations in New Zealand. We present the results in a map detailing the likelihood of OFG in all New Zealand aquifer locations. Subsequent work at locations where OFG likelihood is high can include development of conceptual models for onshore-offshore aquifers, and variable-density numerical modelling to estimate the offshore extent of fresh groundwater. In the longer term, offshore drilling will be required to prove OFG at these locations, however this scoping study is a step towards that goal.

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From trees to clouds: 40 years of progress for the New Zealand Active Faults Database

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Plate boundary processes beneath Te Riu-a-Māui/Zealandia have created, destroyed and shaped the landscape into what it is today. Active faults underlie some major cities and large earthquakes can substantially affect infrastructure, lifelines and life safety; it is thus important to understand the location and characteristics of these structures and associated hazards, such as liquefaction, ground shaking, landslides and tsunamis. The first active fault maps (1970s-80s) were compiled into the Late Quaternary Tectonic Map of New Zealand, which showed 31 active faults but none were accompanied by any fault parameters. Kelvin Berryman and Peter Wood conceptualised the New Zealand Active Faults Database (NZAFD), and along with other key players compiled, shaped, championed and contributed to it significantly over the years. The first digital version was developed in the late 1980s and in the early 2000s it underwent a comprehensive re-design into what is known as the NZAFD today. Forty years on, the database contains ~450 named active faults and >26,000 detailed traces, and ongoing projects continue to add, revise and improve these. This past year, significant updates to the database were made and a new live-streaming capability was developed to deliver single-source-of-truth data to council hazard portals via a Web Map Service. We intend to integrate this service with the NZAFD web map to become a one-stop-shop for accessing active fault information. This database has become a rich compilation of knowledge and a fundamental underpinning dataset to kinematic and seismic hazard modals such as the Active Fault Model, Community Fault Model and National Seismic Hazard Model, and is used to help create Fault Avoidance Zones and Fault Awareness Areas. These datasets are important tools for researchers and are used to inform the public and provide guidance for building codes, land-use planning and decision-making related to earthquake hazard preparedness, response and recovery

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Volcanism between New Zealand and New Caledonia: a stretched Late Eocene to Early Miocene magmatic arc on the Loyalty and Three Kings Ridges

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4A: Volcanism, C1, November 24, 2020, 8:30 AM - 10:30 AM

The 2015 VESPA (Volcanic Evolution of South Pacific Arcs) voyage of N/O l'Atalante dredged rocks from the Three Kings Ridge, Cook Fracture Zone, South Fiji Basin and Loyalty Ridge between latitudes 28 and 24 deg S. Igneous rocks are mainly basalts, with lesser andesites, dacites, shoshonites, and one granite. A total of 46 Ar-Ar ages of groundmass and mineral separates from 28 VESPA lavas almost all lie in the narrow range 25-21 Ma. This is irrespective of water depth (a crude proxy for stratigraphy). Foram ages of limestones associated with lavas and volcaniclastic rocks are also mainly Late Oligocene to Early Miocene (c. 29-19 Ma). Rocks in two western Three Kings Ridge dredges are noticeably older: a mudstone from dredge DR40 contains Late Campanian-Maastrichtian (c. 78-66 Ma) radiolarians, and two lavas from DR25 have Late Eocene (38 and 36 Ma) Ar-Ar ages. The Three Kings granite is a hydrothermally altered biotite porphyry with a U-Pb zircon age of 23.6 ± 0.2 Ma and no older xenocrystic zircon.

Previously, the Loyalty Ridge was assumed to be a Paleocene-Eocene arc. Collectively, our new data indicate a major 25-21 Ma (latest Oligocene to earliest Miocene) pulse of magmatism. This pulse overlaps with and is slightly older than the 23-16 Ma Northland Arc in New Zealand. It overlaps with, and is slightly younger than post-obduction 27-24 Ma granites in New Caledonia. The 25-21 Ma arc lavas were constructed on Late Eocene arc lavas and a Late Cretaceous sedimentary basin. The granite seemingly lies in the footwall block of a low-angle (c. 6 deg) west-dipping normal fault on the eastern side of the Cagou Trough. Our new data supports models of substantial Late Oligocene to Early Miocene syn-magmatic extensional tectonism on the Loyalty and Three Kings ridges.

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High sedimentation rates, earthquakes and the Tuaheni Landslide Complex offshore Tūranganui-a-Kiwa

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2A: Unravelling the Seascape, C1, November 23, 2020, 1:30 PM - 3:30 PM

The Tuaheni Landslide Complex, on the upper slope of the northern Hikurangi Margin, has been studied for over a decade following the interpretation that it is subject to ongoing downslope activity without runaway failure. A number of processes have been implicated as preconditioning and triggering mechanisms, including earthquakes, subsurface gas, static loading and gas hydrates. The most recent investigations have used MeBo and IODP drilling and focused on testing hypotheses related to the role of gas hydrates.

The 145 km^2 landslide deposit in 500-900 m water depth is unsupported on the downslope free face. Surface slope gradients range from 1.5-4° while the interpreted failure surface averages ~2°. The presence of this relatively large debris deposit on the slope with no downslope support is unusual on the Hikurangi Margin where 99% of landslides have no obvious debris deposit associated with the slide scar. In the context of global understanding this is one of the key elements that makes this landslide intriguing: What enables the deposit to shuffle down slope rather than run away? And, what are the hazard implications of large perched landslide deposits?

IODP site U1517 drilled to 187 m through the Tuaheni Landslide Complex and achieved good recovery. Indicators for gas hydrates were observed from ~100 m below seafloor to the BSR depth of ~165 m. Sediments are within radiocarbon dating age allowing a good age model to be developed in combination with biostratigraphic and tephra data. Visual logging, sediment analysis and XRAY-CT image analysis provide insight into the depositional environment of the landslide source material and subsequent deformation of the slide mass. This sedimentary and structural dataset links in nicely with complementary studies on geochemistry, laboratory testing and modelling to provide significant insight into what is now one of the most studied submarine landslides in the world.

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Characterization of tropical Soil Organic Matter by the Rock Eval-6

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Tropical soils represent important carbon (C) reservoirs that are potentially vulnerable to climate change and anthropogenic pressures that affect them in an amplified manner. The great heterogeneity of these environments, as well as the lack of appropriate measurement tools, limits our knowledge, which remains very approximate today with regard to the quantity and quality of Soil Organic Matter (SOM) in intertropical areas. However, this information is necessary to understand the evolution of these soils and their carbon in this context of global changes. The objective of this work is to characterize MOS in intertropical areas. To do this, we tested the application of Rock-Eval pyrolysis for the study of MOS on a regional scale. This technique allowed us to quantify the organic carbon contents at the scale of the study area and to explain its evolution according to a bioclimatic gradient (North, South). Then to observe its evolution in each profile, to make a forest-savanna opposition in order to note the quantitative as well as qualitative differences of the MOS. Then note the impact of soil texture on MOS. Finally, we studied the influence of a tree on the distribution of MOS. This work also confirmed the ability of the Rock Eval6 tool to characterize MOS in intertropical areas.
Keywords: Tropical soils, Rock-Eval pyrolysis, Soil Organic Matter

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Combining organic biomarker and compound-specific stable isotope records with high-resolution sediment imaging to reconstruct environmental and climate changes from New Zealand lake sediments

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8C: Geochemistry, C3, November 25, 2020, 11:00 AM - 1:00 PM

We have used organic biomarkers and compound-specific hydrogen isotopes to reconstruct changes in air temperature, precipitation, vegetation, and water quality over the last ~14,000 years from sediments of a New Zealand lake (Adelaide Tarn). This lake is located on the northwestern South Island in the southern mid-latitudes. It records the climate variability in the Southwest Pacific, which is affected either by the tropical Pacific or by the polar Southern Ocean (i.e., connection to Antarctica). Human impact is minor due to the lake's remote location and the late settlement of humans in New Zealand ~750 years ago.

Tetraether lipids (i.e. glycerol dialkyl glycerol tetraethers; GDGTs) detected in the lake sediments indicate up to ~4°C higher mean annual air temperatures during the last ~5000 years compared to the Last Glacial Maximum and absence of the Holocene Climatic Optimum. We complemented these data with heterocyst glycolipids (HGs), diagnostic indicators of cyanobacteria, that have been proposed as alternative paleotemperature indicators in lakes.

Past changes in precipitation were inferred from δD isotope values of high-molecular weight n-alkanes originating from plant waxes and indirectly from pollen and plant macrofossils, which appear to be particularly sensitive due to the lake's location close to the modern treeline. Long-chain n-alkanes and biomarkers indicative of vegetation (i.e, lupeol, perylene, higher plant steroids, and also more unusual arborinol and fernenol derivatives originating from Poaceae) reflect high terrestrial organic matter supply and changes in vegetation during the past last ~14,000 years.

The biomarker and compound-specific isotope data are compared to pigment records obtained from high-resolution hyperspectral core scanning that can be used to trace changes in lake productivity and we showcase the advantages and drawbacks of the different methods and applied proxies for paleo reconstructions from sediments of this lake.

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GeoNet strong motion data products – modernizing & future-proofing our services

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

GeoNet is an integrated data collection and geological hazards monitoring system. As a non-profit project established in 2001 and operated by the Institute of Geological & Nuclear Sciences Limited (GNS Science), GeoNet offers a highly-integrated facility with a network of geophysical instruments, data collection, real-time monitoring, rapid response and event analysis for natural hazards such as earthquakes, volcanic eruptions, tsunamis and landslides.

One of the key components of GeoNet is the strong motion network. Over 315 strong motion stations in strategic locations all over NZ are equipped with modern instrumentation. This network delivers valued data products including raw and processed data, with services that cater to the requirements of the scientific community.

Currently, GeoNet delivers an ensemble of publicly available strong motion products including time series data, peak ground motion values, response spectral data and Fourier spectra. The wide applicability of these products offers a significant data resource for engineers, seismologists, researchers, and other professionals working on seismic design, ground motion modelling and prediction, hazard and risk assessments and engineering seismology researches.

A continued enhancement and improvement of GeoNet services comes with a more modernized strong motion data products, aligned with the requirements of our end users. As part of modernizing and future-proofing our data services, GeoNet has begun streaming the strong motion seismic data continuously at a high sample rate. This unblocks the strong motion product development for better data access and support services.

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The role of hydrovolcanism in the formation of the Cenozoic monogenetic volcanic fields of Zealandia

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7A: Volcanism, C1, November 25, 2020, 8:30 AM - 10:30 AM

Cenozoic geological evolution of New Zealand centres around the formation of Zealandia, a new continent that became detached from the eastern margin of Gondwana around 105 Ma. Spreading opened the Tasman Sea leaving a fragment of continental lithosphere, largely submerged, in the SW Pacific. Throughout the Cenozoic history, volcanism became an integral part of Zealandia. Continental lithosphere provided the basement for the volcanism, both onshore and offshore. Monogenetic volcanism was common throughout the Cenozoic forming dispersed volcanic fields in the region. These volcanic fields are commonly spread across large territories and linked to older rejuvenated structural elements of the lithosphere. The availability of water was ubiquitous through surface water bodies (oceans and lakes) and various other terrestrial hydrous systems provided by the humid temperate climate of Zealandia. Hydrovolcanism, both explosive and non-explosive, has played a significant role in Zealandia's volcanic history resulting in volcano mega- architecture involving edifice geology and volcanic hazards. The role of external forces that influenced the course of a small-volume volcanic eruptions is significant in the generation of the great diversity of volcanic geoforms of small volcanoes. However, hydrovolcanism has commonly been overlooked in Zealandia's monogenetic volcanism context due to uneven availability of exposures or downgrading its importance in volcano growth in small volcanoes. Cenozoic monogenetic fields of Zealandia particularly provide a unique laboratory and comparative analogy for other volcanic fields on Earth that are associated with low-lying terrestrial settings or shallow marine environments in a humid temperate climate dominated most of the Cenozoic. Here we provide field-based evidences to support our claim that hydrovolcanism is an important elements of the Cenozoic volcanism of Zealandia, especially among dispersed small volume volcanoes where the influence of external forces can be dominant due to the general small volume of magma involvement in each volcano growth.

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Recognition of cryptic igneous intrusions in New Zealand sedimentary basins

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4A: Volcanism, C1, November 24, 2020, 8:30 AM - 10:30 AM

Our petrographic analysis of petroleum well samples from sedimentary basins worldwide has, since 2000, identified a common association of vitric, micro-phenocrystic melt rock, hydrothermal microfabrics and mineralization, high temperature carbon forms, and complex maturity profiles. In 2014/15 analysis of samples from Clipper-1 revealed that native metals of melt origin (Fe, Al, Cu), misidentified globally as sulphides, are frequently represented in this petrographic suite, and that igneous rocks recognised in Clipper-1 are carbonate melts that cannot have sourced native metals directly.
The frequent global occurrence of this petrographic assemblage suggests that intrusion is an important feature in more basins than is generally recognized. However, the mafic intrusions required to source native metals, and melt limestones, are very rarely identified during routine incident light petrography. Also, there is typically no macroscopic evidence of igneous rocks in lithostratigraphic summaries based on drill cuttings and geophysical logs, and intrusive bodies are not recognized on seismic reflection profiles. To address this problem, detailed sampling, elemental analysis (XRF and SEM) and polished thin section petrology has been undertaken as part of the MBIE-funded University of Canterbury 'Buried Volcanoes' research programme.
Polished thin section analysis of drill cuttings from Clipper-1, Resolution-1, Moki-1, Kora-1 and 4 and Waka Nui-1 has identified microphyric, microcrystalline carbonate igneous rocks at all locations. These are particularly common in Pliocene rocks and signal widespread unrecognized intrusive activity at this time. Newly identified mafic to intermediate igneous rocks are provisionally described as microcrystalline to vitric nephelinites, basalt-andesite and andesite-diorite porphyry and gabbroic-diorite rock types. Interactions between magma and host rocks have modified igneous textures and caused intense mineral alteration which mask the occurrence of intrusive lithologies in drill chips and geophysical logs. Over-pressuring resulting from abundant volatiles is postulated to allow the propagation of intrusions that are below the size limit for seismic detection.

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Centroid-moment tensor inversions using 3-D Green's tensor and adjoint method for earthquakes included in full waveform tomography of the South Island region, New Zealand

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

We determine centroid-moment tensor (CMT) solutions by two different approaches: iterative inversion along with minimizing waveform differences between observed and simulated seismograms based on the adjoint-wavefield method and direct inversion from the strain green tensor and observed data. Synthetic seismograms and strain green tensors are calculated using a 3-D viscoelastic wave propagation finite-difference code. The adjoint CMT inversion requires, for each iteration, one forward simulation to obtain synthetics with the current source parameters, one adjoint simulation which back-propagates the differences (adjoint source) between observed and simulated seismograms at the receivers, and extra forward simulations to compute the optimal step length using the conjugate-gradient method. Using the adjoint method, we are able to invert for 6 CMT parameters together with the hypocenter depth. The direct inversion of CMT solutions using 3-D Green's functions requires 3 simulations at each receiver according to the unit-forces applied in 3 orthogonal spatial directions and for all receivers. By extracting the Green's functions at the locations nearby the expected hypocenter, we can invert the CMT solutions from the observed data and determine the optimized solution including hypocenter location from a grid-search. The adjoint CMT inversions are in good agreement with the direct CMT inversion using 3-D Green's functions. We applied the two methods to revise CMT solutions for a number of earthquakes used in the development of the 3-D crustal velocity model for the South Island region, New Zealand, using full waveform tomography. The revised CMT solutions then were included for further tomography inversion to improve the 3-D velocity model.

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Variability of earthquake recurrence intervals; implications for seismic processes and hazards in New Zealand

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8B: Active Tectonics, C2, November 25, 2020, 11:00 AM - 1:00 PM

Recurrence interval (RI) for successive >Mw ~6-7 earthquakes on individual faults is a key parameter for understanding earthquakes and their hazards. These recurrence intervals are most often recorded by paleoseismic datasets primarily derived from trenching fault scarps and dating displaced stratigraphy. The available geological data are point samples that record the largest earthquakes on over 50 individual active faults in New Zealand with slip rates of ~1-30 mm/yr. They become increasingly incomplete with age and, in some cases, could have been generated by events that ruptured multiple faults. The sampled active faults have average RIs of ~130 to 8500 yrs and can vary by more than an order of magnitude with approximately log-normal distributions. Elapsed time since the last event is generally less than the average RI for the faults sampled on individual faults, suggesting that these faults may be in active phases of their earthquake histories or that average RI is overestimated. The available data for individual faults are consistent with earthquake ‘clustering’, variable slip rates through time and multi-fault ruptures. After sampling artefacts have been accounted for, RI data can be used in conjunction with probability density functions, elapsed times, slip rates and rupture lengths for individual faults to improve seismic hazard estimates.

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Dynamic seafloor processes within the Subtropical Frontal Zone on the Chatham Rise and implications for regional sediment and organic carbon budgets

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2A: Unravelling the Seascape, C1, November 23, 2020, 1:30 PM - 3:30 PM

Despite increasing interests in extending extractive industries such as fishing and seabed mining into deeper waters, their effects on deep-sea ecosystems remain poorly understood. As part of the “Resilience Of deep-sea Benthic communities to the Effects of Sedimentation (ROBES)” project, near-seabed sedimentary processes on the Chatham Rise were investigated to improve our understanding of the effects of natural and anthropogenic physical disturbances on the structure and functioning of seafloor communities. Newly designed benthic landers were deployed for ~3 weeks during two voyages in 2018 and 2019, with instruments measuring near-bottom temperature, salinity and dissolved oxygen, currents, turbidity and particle fluxes (sediment traps). Conductivity-Temperature-Depth (CTD) and transmissiometry (particle attenuation) profiles were also collected providing information on dynamic physical processes. Benthic community responses were monitored using camera transects (mega-epifauna) and multi-corer sediment sampling (infauna and sediment oxygen consumption).

Preliminary data show the consistent presence of a 50-100 m-thick benthic boundary layer on the crest of the Chatham Rise, reflecting strong near-bottom currents also recorded by ship-mounted and benthic lander acoustic instruments. These flows led to increases in sediment being resuspended from the seafloor into the water column, resulting in peaks in CTD particle attenuation and turbidity and elevated particle fluxes captured by the lander traps. The trap material comprised a mixture of resuspended benthic (e.g., foraminifera, molluscs, sponges) and pelagic components (planktic foraminifera, faecal pellets). Particle grain-size and organic carbon stable isotope data from the traps and surface sediments from the ROBES voyages corroborate this mixed sediment population. The observations highlight the dynamic nature of near-seabed sedimentary processes within the Subtropical Frontal Zone on the Chatham Rise, and the challenges in disentangling the impacts of anthropogenic seafloor disturbances from natural perturbations in this environment.

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Obliquity pacing of Antarctic glaciations during the Quaternary

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The frequency of Antarctic glaciations during the Quaternary are not well understood. Benthic oxygen isotope records provide evidence for eccentricity paced global ice volume changes since c. 800 000 years and ice core records also appear to have 100 000 year cycles over the last 800 000 years. However, the benthic oxygen isotope records are a global average – not an Antarctic record. Quaternary, sedimentary records proximal to the ice margin (such as the ANDRILL AND-1B record) are needed to understand better the recent glacial history of Antarctica.

Here we present results from the 6.21 m long, NBP03-01A-20PCA sedimentary record which was recovered from the outer continental margin of the Ross Embayment. Sediments comprise mud with numerous clasts and paleomagnetic analyses revealed magnetic reversals at 4.21 m, 5.74 m, and 5.85 m depth. These reversals are correlated with C1n-C1r.1r-C1r.1n-C1r.2r geomagnetic reversals which have corresponding ages of 773 ka, 990 ka, and 1070 ka.

Time series analysis of continuous Anhysteretic Remanent Magnetisation (ARM) data, which are controlled primarily by the concentration of magnetic minerals, revealed strong obliquity paced cycles between c. 800 ka and 350 ka. The presence of obliquity cycles prompted us to carry out core scanning XRF and grain size analyses. We identified obliquity paced cycles in the titanium elemental XRF data over the same period which represent variations in the terrigenous material in the core. Weaker obliquity cycles are also present in the >2mm grain size fraction which we suggest is controlled by the proximity of the ice shelf front.

The presence of obliquity paced cycles in our data indicate that the Ross Ice Shelf advance and retreat cycles were paced with obliquity until at least 350 ka and that the transition to 100 000 year cycles occurred later in the Southern Hemisphere than in the North.

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Possible involvement of overpressured fluid in multi-fault rupture inferred from seismic observations of the 2016 Kaikoura earthquake

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Seismic velocity distributions seem to be correlated with the size of earthquakes. In the case of the 2008 Iwate-Miyagi Nairiku earthquake (M7.2), NE Japan, the lateral extent of the seismic low velocity area beneath the focal area seems to coincide with the aftershock area (Okada et al., 2012).

The M 7.8 Kaikoura earthquake occurred in the northern South Island on 3 Nov., 2016. The Kaikoura earthquake involved the rupture of over 20 faults. This multi-fault rupture was also shown by the multiple aftershock alignments (e.g., Lanza et al., 2019; Kawamura et al., SSJ2020).

To understand the multi-fault rupture of the Kaikoura earthquake, we have undertaken stress tensor inversion using focal mechanisms and seismic tomography along the c. 200 km length of the rupture zone. Data from both temporary stations and GEONET stations were collected from March 2011 to December 2018. Focal mechanisms were determined by HASH (Hardebeck and Shearer, 2002) and stress tensor inversion was done by SATSI (Hardebeck and Michael, 2006). We revised tomography by Okada et al. (2019).

The maximum horizontal stress direction is about N110E both before and after the Kaikoura earthquake. This azimuth is consistent with previous studies (Balfour et al., 2016; Sibson et al., 2012; Townend et al., 2012).

Tomography results show high Vp/Vs in the middle to lower crust occurs not only in and around the hypocenter but also along the northern part of the rupture zone. The high Vp/Vs area and seismic reflectors (Matsumoto et al., JpGU-AGU2020) suggest overpressured fluid in and beneath the focal area.

Spatial correlations between rupture areas and high Vp/Vs suggests the involvement of overpressured fluid in the nucleation and propagation of rupture segments. The involvement of overpressured fluid is also supported by the reactivation of unfavourably oriented strike-slip ruptures, many lying at c.70° to regional sigma-one stress trajectories.

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The Response of Methane Hydrates to Basal Fluid Flow.

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Methane gas hydrate, an ice-like form of water containing methane gas, requires moderate pressures and low temperatures to be stable and is common beneath the seafloor. Geological processes such as sea-level change, tectonic uplift etc. could lead to the “melting” of hydrates with significant implications for seafloor stability and ocean change. In the past decade, several studies have investigated the role these processes play in gas hydrate formation and dissociation in sediments. However, very little is known about the effects of sub-surface fluid flow on gas hydrates. The Hikurangi Margin east of New Zealand is a subduction zone that undergoes significant dewatering leading to advective transport of heat with upward migrating fluid. In this study, we used TOUGH+HYDRATE to study of the effect of warm fluid-flow pulses on hydrate systems on the Hikurangi Subduction Margin. Preliminary results show conductive heat flow dissociates hydrates at the early stages of the simulation.

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Quantifying rates and patterns of erosion on newly uplifted mudstone and limestone rocks at Kaikōura Peninsula South Island New Zealand

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

On rock coasts, estimates of shore platform age and morphology over long timescales have been explored by dating and modelling techniques to infer formative processes from the past. While mathematical modelling scenarios of platforms under climate change effects, waves, tides and rising sea levels indicate that they develop by downwearing and backwearing processes, there has been no clear linkages between the formative processes. In New Zealand with recurring tectonics and sea level change, predicting the response of slowly eroding rocks to environmental change is difficult due to the competition between constructive and destructive processes. While quantitative wave and erosion data have provided insights to shaping mechanisms, there has been less emphasis on the role of tectonics in platform development (Berryman is an exception). Most erosion rates and wave data have been measured before uplift events so there is an absence of erosion data that record how rocks adjust (either fast or slow) and respond to changing environmental processes immediately after an uplift event. Therefore, using high-resolution 3D topographic data from micro-erosion meters and structure-from-motion (SfM) photogrammetry, this study seeks to monitor and record rates and patterns of erosion on uplifted mudstones and limestone shore platforms around Kaikōura Peninsula, New Zealand following the November 2016 Mw 7.8 Kaikōura earthquake. This event offers a once in a lifetime opportunity to compare erosion dynamics post-earthquake erosion data with 43 years of pre-earthquake data. These erosion measurements will make a significant contribution for improved models of shore platform development and better understanding of rock coast response to both sudden and gradual environmental change.

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AF8: Five years of science and emergency management collaboration to improve resilience in the South Island.

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7B: Active Tectonics, C2, November 25, 2020, 8:30 AM - 10:30 AM

AF8 [Alpine Fault magnitude 8] is a collaboration between Civil Defence Emergency Management and the Alpine Fault science community, which began in 2015. Its aims include improving response capability for a future Alpine Fault earthquake, and increasing risk literacy and preparedness amongst individuals, communities, agencies and organisations in light of the potential impacts and consequences of a future Alpine Fault earthquake. The SAFER Framework (South Island Alpine Fault earthquake response) was delivered at the end of the second year of work in 2018, and was built on a strong science foundation through the use of a scenario-based approach. The science scenario was developed by a team of 30 Alpine Fault specialists, including Kelvin Berryman, using the best science available at the time. The scenario was then workshopped across all six CDEM groups in the South Island, which informed the architecture of the SAFER Framework. The science scenario has provided the basis for extensive science outreach and engagement by the AF8 Science team in subsequent years, and stimulated considerable hazard and risk-related research.

AF8 has invested time and resources into delivering engaging science content, much of which is based on the research contribution made by Kelvin Berryman and his colleagues. Kelvin is a strong advocate for delivering science into practice and policy, and his support and encouragement of AF8 from the beginning has been instrumental; firstly his endorsement of the work, which enabled AF8 to bring together the best team of scientists from the outset. He has also actively and willingly contributed to AF8 outreach and engagement activities, including the AF8 Roadshow and other science communication efforts, and encouraged a risk-based approach to current and future research. His involvement in AF8 as a mentor, advocate and whole-hearted supporter has been instrumental to the success of the programme, and we would like to acknowledge his significant contribution.

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HADAL sediment cores recovered from >9000 m water depth contain evidence of life and turbidites in the Kermadec Trench

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2A: Unravelling the Seascape, C1, November 23, 2020, 1:30 PM - 3:30 PM

Material collected as part of the collaborative international HADAL project exploring the ocean's deepest extreme environments collected several cores from four deep basins in the Kermadec Trench in 2017. Recovered using the RV Tangaroa from >9,000 m water depth, they currently represent the deepest sediment cores ever collected from the New Zealand EEZ. New computed tomography (CT) scans of the cores show density contrasts and reveal that the seabed is composed of finely laminated mud, likely to be caused by successive turbidity flows. One turbidite base is composed of angular, very coarse sand-sized clasts, of likely volcanic origins. Given that the Kermadec Trench is the manifestation of the Australian and Pacific plate subduction boundary, earthquakes will influence seascape stability and are plausible triggers for turbidity flows. One core shows an essentially structureless bioturbated seafloor. Oxygen microprofile data suggest a more complex picture where elevated bacterial activity was noted in turbidite-rich seafloor A relatively rich infaunal community was found, which was dominated by nematodes (including several species new to science) and with densities in excess of 200 individuals per 10 cm2 of seabed. The HADAL team seek to understand how trench ecosystems are nourished by carbon inputs, potentially from turbidity flows, at various trenches around the Pacific. The 16 June 2020 M7.0 earthquake in the Kermadec Trench could have triggered another turbidity flow and transported new material into the deepest reaches of our EEZ. Revisiting the 2011 study site following this recent earthquake might provide unique insights into the initial influence of turbidity flows on life in the deepest part of our ocean.

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Rapid weathering and slow erosion of an actively exhuming metamorphic core complex in tropical Papua New Guinea

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Understanding what drives weathering and erosion is key to understanding the interactions between tectonics, climate, topography and vegetation and their impacts on landscape evolution. While conceptually the roles of climate, tectonic uplift, topography and vegetation are generally well understood, disentangling their relative contributions to erosion and weathering rates has proven difficult. A previous study from tectonically stable, tropical Sri Lanka showed that denudation rates are extremely low, despite high mean annual temperature and precipitation. The implication of this work is that tectonic setting exerts a stronger control on denudation than climatic setting. However, the contribution of chemical weathering to these denudation rates may be substantial. To establish the relationship between weathering and erosion rates in tropical settings more work is needed. To this end, we collected stream sediment and soil samples from the Suckling-Dayman metamorphic core complex (SDMCC) in Papua New Guinea. The footwall of the SDMCC has been uplifted over the last ≃4 Ma along the Mai'iu Fault. The domed and striated morphology of the SDMCC suggests that it is minimally eroded, aside from deep fluvial incision of several north-flowing drainages. Cosmogenic nuclide-derived slip rates on the Mai'iu Fault suggest vertical uplift rates of >3mm/yr. Such rapid uplift would normally be assumed to result in rapid denudation of these mountains. However, [^{10}Be] in quartz grains from soils and stream sediment indicate orders of magnitude slower denudation, between ≃0.03 and ≃0.18 mm/yr. Enrichment of immobile and depletion of mobile elements in soils overlying the basaltic footwall of the SDMCC indicate rapid, near-complete weathering. We suggest that the tropical climate, combined with easily weathered metabasalt bedrock, lead to the creation of a soil and vegetation carapace that protects the bedrock from erosion. We suggest that climate may play a key role in limiting denudation rates in actively uplifting tropical mountains.

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The Seabed 2030 Project: Collating bathymetry data in the South&West Pacific Ocean

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2A: Unravelling the Seascape, C1, November 23, 2020, 1:30 PM - 3:30 PM

The Seabed 2030 Project is a collaborative project between the Nippon Foundation and GEBCO (General Bathymetric Chart of the Oceans), which aims to create the complete map of the world ocean floor by 2030. To date, the Seabed 2030 efforts have increased the coverage achieved by direct acoustic measurements from 6.2% in the GEBCO_2014 30arc-sec grid to 20% in the GEBCO_2020 15arc-sec grid.

One of the key objectives of Seabed 2030 is to Seabed 2030 has four regional data centres that compile bathymetric grids. The South and West Pacific centre assembles data over the region from South America to Australia and to the NW part of the Pacific Ocean up to Japan. Data integration is performed within the ESRI Bathymetry database, using the custom configuration of metadata defined by Seabed 2030. The Centre maintains an Open Geospatial Data page that provides capabilities for visualization of the bathymetric data coverage.

One of the key objectives of Seabed 2030 is to discover bathymetric data that are not yet included into the global GEBCO grid, including data from varied methods such as MBES, SBES, 3D seismic, beach-profiles, etc. The other objective is to identify areas that have not been mapped but could be covered by future research cruises and ship transits. The project remains a global challenge that can only be accomplished through national and international collaboration.

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How McKee Oil Field changed the petroleum scene in New Zealand

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3C: Petroleum, C3, November 23, 2020, 4:00 PM - 5:30 PM

The discovery the McKee Oil Field, in eastern onshore Taranaki Basin, 40 years ago, in September 1980 changed the way explorers viewed New Zealand. No longer were we just a gas-condensate region we now produced our own indigenous oil. McKee was New Zealand's first commercial oil field flowing, on initial test 1750 barrels (235,000 litres) of oil and 26,000 cubic metres of gas per day. The first oil to the surface was brownish yellow in colour and became solid (due to its wax content) after it had sat in the collection cans for a while. That colour soon changed to a light to medium brown coloured oil after it had reliquefied. The discovery well, McKee-2, was the second well to drill the structure. While McKee-1 indicated the presence of hydrocarbons the quantities were insufficient to flow. McKee Field produces from a late Eocene sandstone reservoir trapped within an overthrust structure. The McKee Structure is part of the Tarata Thrust Zone in eastern onshore Taranaki. Earlier wells, including Urenui-1, had drilled overthrust structures but it was the McKee wells and subsequent drilling to the north (Pouri and Pukemai) and south (Toetoe) that defined and delineated the Tarata Thrust Zone.

McKee produces a waxy crude oil. It's a high quality oil but only a proportion can be handled by New Zealand refinery at Marsden Point. The refinery, which began production in 1964, is designed for lower grade and heavier Middle East crude oil. Our high grade light oil fetches higher prices on the international market, mostly in Australia and Singapore, earning New Zealand valuable export dollars. In a little over 25 years the McKee Field produced just under 48 million barrels of oil

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In-situ Scheelite REE geochemistry reveals evolving fluids during orogenic Otago Schist gold-tungsten mineralisation in New Zealand

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7C: Minerals, C3, November 25, 2020, 8:30 AM - 10:30 AM

Characterisation of scheelite compositions from multiple deposits across the Otago Schist reveal distinctive compositions for shallow vs deeply sourced mineralisation. Scheelite samples from historically economic scheelite deposits at Glenorchy, Macraes and Bendigo were investigated and compared to samples from weak scheelite mineralisation at Boanerges Peak in the Southern Alps. Cathodoluminescence imaging (CL) reveals primary growth zonation within single grains of the Glenorchy, Macraes and Bendigo scheelite samples. Blue CL corresponds to low total REE concentrations and flat to u-shaped REE patterns, as determined by in-situ LA-ICPMS, whereas orange or reddish blue CL corresponds to higher REE concentrations and flat to n-shaped REE patterns. In-situ LA-ICPMS Sr isotope compositions are homogenous within single grains. Boanerges Peak scheelite have homogenous blue CL and the lowest total REE concentrations with a wide variety of REE patterns from thin-section to outcrop scales. Variations in Sr isotope compositions of scheelite are more radiogenic in veins hosted in argillite vs veins hosted in greywacke. We propose that scheelite compositions of the Glenorchy, Macraes, and Bendigo samples primarily reflect fractional crystallisation of scheelite from fluids of similar compositions despite significant spatial and temporal separation and being hosted within different structural settings and host rock types, consistent with a regional source of the mineralising fluids. On the other hand, Boanerges scheelite compositions show considerable REE and Sr isotope variations that can be linked to host rock lithologies consistent with local derivation of mineralising fluid components. These results support the current orogenic Au-W mineralisation model for the Otago Schist.

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Seismo-acoustic observations during the 2018 Ambae (Manaro Voui) eruption, Vanuatu

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Ambae volcano (Manaro Voui) is one of the most active volcanoes in Vanuatu; recent eruptions highlight the need for campaign monitoring and research to better understand the hazard. Phreatic and phreatomagmatic eruptions occurred in 2017–2018, causing emergency evacuation of all residents to neighbouring islands. During the last episode of the 2017–2018 eruptive sequence, GNS Science and Vanuatu Meteorology and Geohazards Department (VMGD) collaboratively operated a temporary network of seven broadband seismic sensors and four 3-element acoustic arrays. Analysis of seismo-acoustic data provides valuable information of eruption dynamics as well as volcano plumbing system. Here, we present general seismic and acoustic observations at Ambae volcano and suggest useful approaches that could improve interpretation of the volcano monitoring system and hazard mitigation measures.

We hypothesized that eruption activity produces peak seismo-acoustic energy prior to the development of large ash clouds and that the signal energy can be used to estimate ash plume height. To confirm the feasibility of our hypothesis, we initially analysed five ash eruptions reported by Volcanic Ash Advisory Center (VAAC), Wellington. Peak seismo-acoustic energy was observed at least 40 min before VAAC reports were issued, and was proportional to ash cloud height. We then detected unreported explosions through a reverse time migration method and compared their energy to ash heights. In addition, we examined source locations of local tectonic earthquakes and volcanic tremor using a traditional pick phase approach and an amplitude source location method, respectively, to understand the plumbing system. The relationships from this study may support improved ash plume monitoring for regional and global aviation safety.

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Can trace metals in deep-sea corals provide information about nutrient behaviour in the waters around New Zealand?

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The waters around New Zealand are highly productive, stimulated by an abundant supply of macronutrients (nitrate and phosphate) from the Southern Ocean. However, the ocean currents responsible for the transport and mixing of different water-masses are variable over decades to millennia, implying that marine productivity may also vary on similar timescales. Two major projects are presently underway to reconstruct past ocean circulation and productivity around New Zealand using the skeletons of long-lived deep-sea corals. However, we lack a way to directly track nutrient concentrations; an important missing piece of the puzzle. Here we investigate the possibility that micronutrient trace metals (e.g. Cd and Zn) in corals could be used as proxies for their macronutrient counterparts.

Micronutrient trace metals have oceanic distributions closely matching marine phosphate and nitrate. This similarity has been exploited in other marine organisms to allow the reconstruction of macronutrients. However, the use of trace elements as nutrient proxies in deep sea corals is still in its infancy, and much remains unknown. For example, corals could incorporate trace elements from their food (particulate organic matter from the surface), or from the ambient water at depth. To investigate this, we are measuring trace elements in both calcareous bamboo corals and organic-skeleton black corals from multiple locations around New Zealand. We aim to determine whether trace metals show a consistent pattern of variation, whether species or ontogenetic factors affect trace element concentrations, and whether they track surface or deep-water nutrient distributions around New Zealand. Here we present preliminary results from 50 black coral samples analysed by sector-field solution ICP-MS at Victoria University of Wellington and calibrated against recent trace element geochemical data from southwestern Pacific GEOTRACES datasets.

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Measuring landscape evolution from inception to senescence; an example from the Cooloola Sand Mass, Australia

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4C: Sediments, C3, November 24, 2020, 8:30 AM - 10:30 AM

The concept of the geomorphic cycle underpins much of geomorphology, but the topographic evolution of a single landscape from inception to senescence has not been demonstrated in nature. The Cooloola Sand Mass (CSM) in eastern Australia preserves dune landforms from initial formation to the achievement of maturity (morphologic steady-state). Based on observations from the CSM, we propose that the standard deviation of curvature (σC) is a proxy for the stage of evolution of a landform and gives insights into the mechanisms controlling this transformation. We demonstrate that dunes exhibit hillslope curvature (C) distributions centred on planar surfaces (0 m-1) and these distributions narrow with time. The σC systematically decreases from 0.074 to 0.012 m-1 over a ca. 9.8 kyr period. There are two processes at work. Soil creep mechanisms operate continuously to smooth the dune surfaces, while a rapid decline in surface roughness within the first two thousand years after emplacement is due to the dominance of episodic mass movement. Here we demonstrate that the σC represents a landscape's potential for change and is inherently integrative. Its normalisation can be used to measure and define the evolution of topography in a way that traditional geomorphic measurements cannot.

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Seafloor pockmarks on the Chatham Rise and Bounty Trough – an overview on R/V Tangaroa Voyage 2006

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3A: Unravelling the Seascape, C1, November 23, 2020, 4:00 PM - 5:30 PM

Over 50,000 km^2 of the seafloor on the Chatham Rise and Bounty Trough are covered by pockmarks. Geochemical data from previous studies rule out that sudden methane escape led to the formation of these pockmarks, the most commonly suggested cause for seafloor pockmarks. We hypothesize pockmark formation is linked to repeated release of CO_2 from the Hikurangi Plateau based on the geographic coincidence between the pockmark region and the Hikurangi Plateau and pronounced $\Delta^{14}C$ anomalies observed in sediments deposited during the last glacial termination. Voyage TAN2006 in July 2020 aimed at collecting high-resolution seismic, sub-bottom profiler, and multibeam bathymetry data in selected regions of the pockmark fields to study the sub-seafloor plumbing system, reflectivity patterns in the pockmarks, timing of pockmark formation, and reconstruction of pockmark infill. We collected densely-spaced seismic 2-D data over an area of 6x2 km^2 that will be processed for generating a pseudo 3-D cube. This cube covers seafloor pockmarks typical of a >1000 km long swath along the southern Chatham Rise in water depths of 500-700 m. Additional 2-D seismic data were acquired to allow a stratigraphic tie of the study area into an industry survey, as well as across a core site in the Bounty Trough with a strong $\Delta^{14}C$ anomaly. The latter profile also targeted drift deposits in this region. We also acquired nearly 3000 km of TOPAS sub-bottom profiler data, including a dense grid across the pseudo 3-D cube as well as coincident multibeam data. These profiles constitute site survey data for proposed scientific IODP drilling. We will present first results from this voyage.

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What controls the along-strike segmentations of shallow slow slip events? Insights from 3D numerical modeling of slow slip events along the Hikurangi margin, New Zealand

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6B: Transition Zone, C2, November 24, 2020, 2:30 PM - 4:30 PM

Over the last two decades, geodetic and seismic observations have revealed a spectrum of slow earthquakes along the Hikurangi margin. Of those, shallow slow slip events (SSEs) that occur at depths of less than 15 km show a strong along-strike segmentation in the location of slip patches and recurrence intervals, which vary from ~1 to 5 years from offshore Tolaga Bay to Cape Turnagain. To understand the factors that control this segmentation, we conduct numerical simulations of SSEs incorporating laboratory-derived rate-and-state friction laws and either a planar or a non-planar fault geometry. Among a wide range of parameters considered here, we find that a relatively simple model assuming non-planar fault geometry given by a recent model of the plate interface can reproduce the observed segmentation of shallow SSEs. Our preferred model shows a spatial pattern of magnitudes and durations of SSEs that is consistent with observations, and captures the northward decrease of their recurrence interval. The longer recurrence interval of SSEs offshore Cape Turnagain is favored by the shallower dipping angle of the fault and the lower convergence rate, whereas in the northern part of the margin, the higher plate convergence rate and steeper dip angle lead to shorter recurrence times of SSEs. Our results indicate that the segmentation of SSEs is mainly controlled by both the rate of plate convergence and along-strike changes in the plate geometry. We also find that, although the first-order segmentation of SSEs could also be reproduced using the planar fault geometry, the model with the more realistic non-planar geometry fits better the recurrence intervals of SSEs. These results may help explain the segmentation of SSEs observed in other subduction zones as well, such as Nankai and Mexico.

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Early and middle Miocene ice sheet dynamics in the Ross Sea: Results from core-log-seismic correlation

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1C: Cryosphere, C3, November 23, 2020, 11:00 AM - 12:00 PM

Evidence for the intermittent oscillations of grounded ice during early and middle Miocene are partly preserved in the sedimentary record from the Antarctic continental shelf. Widespread subglacial erosion occurred during major ice sheet advances, while open marine deposition occurred during times of ice sheet retreat. Data from seismic reflection surveys and drill sites from Deep Sea Drilling Project (DSDP) Leg 28 and International Ocean Discovery Program (IODP) Expedition 374, located along the present-day middle continental shelf of the central Ross Sea, indicate the presence of expanded early to middle Miocene sedimentary sections. These sections include the Miocene Climate Optimum (MCO ∼17-14.6 Ma) and the middle Miocene Climate Transition (MMCT ∼14.0-13.8 Ma). Drill core records and wireline logs are used to constrain interpretations of seismic isopach maps and document the evolution of different ice sheets and ice caps which influenced sedimentary processes in the Ross Sea through the early to middle Miocene. In the early Miocene, periods of localized advance of the ice margin are revealed by the formation of extremely thick sediment wedges that prograded into the basins. At this time, morainal bank complexes are distinguished along the basin margins, suggesting sediment supply derived from marine-terminating glaciers. During the MCO, biosiliceous-rich sediments are regionally mapped within the depocenters of the major sedimentary basins across the Ross Sea, indicating widespread open marine deposition. At the MMCT, a distinct erosive surface is interpreted as representing large-scale marine-based ice sheet advance over most of the Ross Sea paleo-continental shelf. The regional mapping of the seismic stratigraphic architecture and its correlation to drilling data

indicate that a regional climatic transition from isolated ice caps to widespread ice sheets occurred through Miocene in the Ross Sea.

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Hydrogeochemical controls on the uranium isotope systematics of New Zealand rivers: Implications for the reconstruction of past ocean oxygenation changes.

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8C: Geochemistry, C3, November 25, 2020, 11:00 AM - 1:00 PM

An invariant uranium (U) isotopic ratio ($^{238}U/^{235}U$) was traditionally assumed for the entirety of the Earth. However, recent technological advances have demonstrated subtle, yet well-resolvable, 0.1%-level variations in natural U isotope compositions. The $^{238}U/^{235}U$ system primarily undergoes isotopic fractionation in response to changes in redox chemistry, and a rapidly evolving application is the study of past ocean oxygenation status that can modulate global carbon and climate cycling through the preservation of organic matter. Accurate reconstruction of past ocean oxygenation using $^{238}U/^{235}U$ requires the isotopic composition and the mass fluxes of U sources to be well constrained, since these are considered to be in equilibrium with the known sinks. The primary source of U into the ocean is via riverine input. However, the hydrogeochemical controls on riverine $^{238}U/^{235}U$ remain underconstrained, which introduces significant uncertainty into climate models that use $^{238}U/^{235}U$ as a proxy for past ocean oxygenation.

The concentration of U in New Zealand river water displays some of the largest variability globally. This provides an important study region for constraining the hydrogeochemical controls on U isotope systematics with both regional and global importance. This study integrates the isotopic composition of strontium ($^{87}Sr/^{86}Sr$) and trace metal concentrations as weathering tracers, geochemical modelling and statistical analysis with the $^{238}U/^{235}U$ and $^{238}U/^{234}U$ compositions of New Zealand river waters to better constrain the hydrogeochemical controls on U isotope systematics. Filtered waters were obtained from fifteen discrete rivers, and include spatial and temporal variation within catchments across the South Island/Te Waipounamu. This study incorporates a broad spectrum of potential drivers of natural $^{238}U/^{235}U$ compositions, including tectonic uplift, rainfall and catchment area lithology. This study demonstrates that a re-evaluation of the global ocean U isotope budget is required, which will considerably minimise uncertainty in modelling investigations using $^{238}U/^{235}U$ as a proxy for past ocean oxygenation.

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Interconnected Geoscience for International Development

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8A: Geo-Teaching & Practice, C1, November 25, 2020, 11:00 AM - 1:00 PM

Spending in international aid programmes from governments and other agencies represents a >> $100Bn US investment annually. International development and global environmental management greatly benefit from the application of high quality and appropriate geoscience and related expertise. Barriers exist, particularly between research-intensive geoscience organisations and development agencies, that inhibit the greater application of geoscience within development. Key barriers include differing world-views, performance rewards and values. This paper argues that geoscience can rapidly evolve in its importance and application to complex regional and global, development and environmental challenges. Changes in ethos, performance rewards, attitudes, and culture, will drive an increase in relevance. Case studies are presented, from Afghanistan, and Solomon Islands, to illustrate how geoscience approaches can be applied, within complex multi-faceted development contexts, with consequent outcomes and challenges. Lessons can be learned from such case studies to develop interconnected approaches. A conceptual model is presented of 'interconnected geoscience', defined as: 'a philosophy that combines geoscience expertise with an equivalent expertise/consciousness in the understanding of developmental situations, conditions, and context, including the integration of diverse 'world views/wisdom and values', placing development-goals at the heart of the interconnected-approach'.

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Monitoring the locked to creeping transition of the Hikurangi Subduction Zone near Porangahau using repeating earthquakes

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The Hikurangi subduction zone exhibits a variety of fault-slip related phenomena from large megathrust earthquakes to slow-slip. The northern Hikurangi margin hosts shallow slow-slip and is weakly coupled to shallow depths. In contrast, the southern Hikurangi margin is strongly coupled, and only deep slow-slip has been observed. The transition in coupling occurs beneath the township of Porangahau, and is an exemplary focus region for studying how this change in locking is accommodated.

To examine slip processes beneath Porangahau, we have constructed and analysed a catalogue of repeating earthquakes that occurred between 2004 and 2018. Repeating earthquakes are thought to re-rupture the same fault-patch at different times, and thus have nearly identical waveforms, locations and magnitudes. Because repeating earthquakes represent cyclic loading, they can be used to detect temporal and spatial changes of slip-rate at depth and hence monitor how stress is transferred to seismogenic zones.

To build our catalogue of repeating earthquakes we first clustered the GeoNet earthquake catalogue by distance and correlation to identify potentially repeating events. We then used a stronger cross-correlation threshold of at-least 0.95 normalised cross-correlation on three or more stations to identify repeating earthquakes from the initial clusters. This threshold was determined by our group's previous work on the northern Hikurangi margin. We identified 236 families of repeating earthquakes, with each family having at-least two earthquakes in our 14-year study period.

We computed precise absolute locations and focal mechanisms of all 236 families and their constituent earthquakes via a combination of manual phase-picking and cross-correlation pick-correction. High waveform-similarities enabled us to obtain precise relative magnitudes. The spatiotemporal analysis of repeating earthquakes and their changes in time improves our understanding of how the Hikurangi subduction zone is being loaded at this transition zone.

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The Taupō 232 CE eruption: Processes, products and an assessment of environmental impacts

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The latest explosive eruption of Taupō supervolcano at ~232 CE is one of the largest and most violent eruptions globally over the past 5,000 years, with extensive pumice deposits that can be found across the North Island. It is notable for several key characteristics including variable magma-water interaction during the early phases, a particularly powerful plinian plume and a widespread unwelded ignimbrite. However, many questions remain around the timing of the eruption, distal dispersal characteristics, and the short- and long-term impacts on vegetation and climate. We have investigated different palaeoenvironmental records that contain Taupō tephra to reassess the nature and impacts of the eruption. First, pollen records from various lake cores across the North Island have been assessed to investigate the impacts of the eruption on vegetation and to estimate recovery timescales. They indicate that the degree of forest damage is not always proportionate to the thickness of tephra deposited. Second, peat bogs throughout North Island have been cored to investigate the dispersal characteristics of the different phases of the Taupō eruption. Initial results suggest that distinct layering from eruptive subunits are preserved at distal sites, which have been previously overlooked or are missing from lacustrine records. Peat bog and terrestrial depositional records also provide new information about the power of the umbrella cloud that resulted from the catastrophic final phase of the eruption during ignimbrite emplacement. This information will be used to refine ash dispersal models and critically evaluate the nature of the ash plume. Finally, ice core records from Antarctica preserve abrupt microparticle and sulphate spikes that coincide with the Taupō eruption. These intervals will be melted and analysed to geochemically fingerprint Taupō-derived glass shards that will pinpoint the exact timing of the eruption and enable any volcanically-induced climate forcing to be quantified using water isotope records.

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Progress towards integrating the onshore and offshore paleoseismic record on the central Hikurangi subduction margin

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7B: Active Tectonics, C2, November 25, 2020, 8:30 AM - 10:30 AM

The Hikurangi margin presents an ideal natural experiment for understanding spatio-temporal variability in slip behaviour due to along-strike variability in interseismic coupling. An emerging paleoseismic record reveals potential evidence of large subduction earthquakes on the central margin which is currently thought to be weakly-coupled and characterized by slow slip. However, a more precisely dated and spatially extensive paleoearthquake chronology is required before robust conclusions can be drawn regarding the location of subduction interface rupture patches.

To improve the paleoseismic record for the central Hikurangi margin we aim to refine the paleoearthquake records from the Hawkes Bay and integrate them with offshore records generated using turbidite paleoseismology. The Pakuratahi Valley in the Hawkes Bay has been identified as a prospective location for reconstructing land-level changes associated with subduction interface rupture, and may archive evidence of paleotsunamis. The site is optimally placed to complement the existing subduction earthquake record from nearby Ahuriri Lagoon, thus providing a greater spatial extent on the crustal deformation, and potentially higher precision earthquake ages. Despite this, preliminary investigation of coseismic subsidence in the Pakuratahi Valley presents mostly asynchronous earthquake ages when compared with the record from Ahuriri. This makes attributing a subduction interface source problematic given the high density and sparse mapping of the upper plate faults in the region, as both sites should record subduction earthquake events coevally.

To complement the onshore paleoseismic record we will develop turbidite paleoseismic records from the Hawkes Bay, Madden Canyon and Pahoa Canyon distributary systems. Identifying synchronously triggered, spatially-extensive ground shaking will increase the robustness of attributing a subduction interface source, and combining the distribution of this with onshore evidence of coastal deformation will allow us to estimate the rupture patches of past subduction earthquakes.

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Process sedimentology of the Waikato River mouth, Port Waikato, New Zealand

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4C: Sediments, C3, November 24, 2020, 8:30 AM - 10:30 AM

Nearshore and shallow marine depositional systems are well studied from a sedimentological and stratigraphic standpoint. However, sedimentological facies models do not capture the short-term complexity of depositional processes in mixed-energy environments (i.e., mixture of river flow, tides, and waves). Here, we use the Waikato River, the longest river in New Zealand, to examine process-response sedimentology. Sedimentological data from the river mouth is scarce, but a prominent barrier sand bar occurs over which river flow, tides, and waves interact. The aim of this study is to answer the following research questions:
1) Can depositional processes be recorded using oceanographic instrumentation and linked to the corresponding sedimentary deposits?
2) Is the sedimentary record biased towards certain processes operating at specific timeframes?

Four data sets were collected in January 2020: 1) surface and channel sediment samples, 2) bathymetry and topography surveys, 3) vibracores, and 4) process data from oceanographic instruments. Results show that the field area is dominated by medium-grained sand (0.250-0.500 mm). Cores present planar-parallel lamination and trough-cross stratification, linked to surface bedforms. Oceanographic instruments record flow velocities up to 1.3 m/s, and multi-directional currents orientated north-south and east-west. The combinations of river flow and tides leads to strong asymmetry between flood and ebb flow velocities. Fast flow velocities exist throughout most of the inundated period, with potential for deposition only occurring during early ebb tide.

These results suggest that waves are an important agent of erosion and sediment re-working, and tidal fluctuations in water level determine the efficacy of erosion; however, deposition is primarily controlled by river flow. This study is significant because it shows that erosional and depositional processes vary in river-mouth settings on various time scales, highlighting the difficulty in interpreting physical processes (e.g. river flow, tides, or waves) in similar mixed-energy environments within the rock record globally.

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The role of atmospheric rivers in snow hydrology of the Southern Alps

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1C: Cryosphere, C3, November 23, 2020, 11:00 AM - 12:00 PM

The mid-latitudes Southern Alps are a key landscape feature that shapes the hydrology of alpine rivers in the South Island of New Zealand. Seasonal snow is an important element of water resources in alpine catchments of the Southern Alps which influence the timing and magnitude of the alpine river flows. In mid-latitudes a sizeable fraction of moisture is transported through atmospheric rivers (AR). ARs are narrow channels of enhanced water vapour within the atmosphere that are responsible for horizontal transport of moisture outside of the tropics.

Previous research has highlighted the potential role of ARs as important drivers of solid precipitation; however, their role in hydrological processes of snow dominated regions is still largely unknown in many parts of the world including the Southern Alps. Therefore, the primary objective of this study was to explore the role of ARs in producing large snowfall events and major rain-on-snow (ROS) events in the Southern Alps.

Our results show that about 70% of large snowfall events across the Southern Alps are associated with ARs. Analyses of the hydrometeorological characteristics of the ten topmost ROS events over a period of eight years (2010-2018) near the Main Divide of the Southern Alps was also conducted. A strong association between ARs and the occurrence of ROS events in the Southern Alps was found. ARs were found to be responsible for nine out of ten identified ROS events. Despite being more common during October and November (8 out of 10), ROS events also occurred during the colder months of June and September. Observations of alpine river flows during the passage of ARs provided evidence that a combination of persistent heavy rainfall and intense snowmelt can generate significantly high peak flows in the upper terrains of the Southern Alps resulting in major flooding in alpine rivers.

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Recent Debris Flow Activity on Takaka Hill, Tasman District

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The passage of Ex-Tropical Cyclone Gita on 20th February 2018 across the northern parts of Te Wai Pounamu, Aotearoa, triggered extensive slope failures across Tasman District, particularly on the south-facing slopes of Takaka Hill. This resulted in major damage to and temporary closure of State Highway (SH) 60 linking Motueka and Golden Bay. As well as being a popular tourist route, SH60 is the only lifeline link for residents of Golden Bay. Over a year after the event SH60 is still reduced to a single lane at several locations. Investigation of both the 2018 and recent historical debris flow activity indicates that extreme precipitation events are the main trigger for debris mobilisation from the slopes above and drainage channels crossing SH60. Across the region rainfall in February 2018 exceeded 180mm in 12 hours. Rainfall radar indicated that this rainfall was localized to a narrow swath. Two types of slope failure are observed on Takaka Hill: shallow slides and channelised debris flows. The shallow slides have slip surfaces at depths ≤ 3m, often at the contact between colluvium and the underlying weathered bedrock. Lithologies along the highway segment include basic and ultramafic intrusive rocks, schist, and granitic rocks, each with its own particular weathering profile. Along with conducting detailed engineering geomorphological mapping and determining geotechnical properties of the slope forming materials, ground profiles from MASW and GPR surveys indicate the magnitude of prior debris flow events.

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Past natural hazards, environmental change, and oral traditions in Polynesia: case studies from Tikopia and Rapa Nui (Easter Island)

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4B: Hazards, C2, November 24, 2020, 8:30 AM - 10:30 AM

The popularised accounts of pre-European contact Rapa Nui (Easter Island) and Tikopia rely heavily on the interpretation of archaeological, palaeoecological, and geoscience data. Oral traditions of tribal conflict on Rapa Nui continue to be used as corroborative evidence for resource exploitation and deforestation. Here we use microfossil, charcoal particle, and geochemical analyses of contiguous lake and swamp sediments from these remote Polynesian islands, spanning the period of Polynesian colonization, to assess the respective popularised accounts of environmental change on both islands. On Tikopia, we have identified tsunami debris generated by the mid-fifteenth century Kuwae caldera collapse, 500 kilometres southwest of the island, which expanded coastal sand flats, and impounded a marine embayment and mangrove forest, to form a lake and swamp. Tribal genealogies and traditions of a tsunami provide a matching chronology for this event. We attribute mangrove forest extinction in the sixteenth century to increased pressure for expanding cultivation due to rapid population growth inferred from faecal sterol measurements and other fossil indicators. We also link regional reconstructions of seventeenth century climate deterioration to fossil evidence for tree crop failure and post-European contact depopulation on Tikopia, but also to Polynesian traditions of conflicts over food shortages which culminated increased tribal conflict. The exceptional depiction of the Kuwae-Tsunami on Tikopia, and at the source (Ballard et al.), indicate that catastrophic environmental changes figure highly in Pacific Island societies. Yet on Rapa Nui, sedimentary archives do not reliably record the timing and extent of forest decline prior to European arrival, nor are there any references to environmental catastrophes in oral traditions. Transdisciplinary approaches to reading of the accumulated evidence for environmental change on these islands are discussed, focusing on how indigenous narratives of the past may inform the geosciences.

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The 2.1 Ma Waiteariki Ignimbrite: defining a new super-eruption at the onset of TVZ volcanism

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5A: Volcanism, C1, November 24, 2020, 11:00 AM - 1:00 PM

The crystal-rich c. 2.1 Ma Waiteariki Ignimbrite is the most voluminous and prominent volcanic deposit associated with volcanism in the Tauranga-Kaimai region c. 2.9-1.9 Ma. During this time, subduction-related volcanic activity transitioned from the older Coromandel Volcanic Zone (CVZ) to the currently active Taupo Volcanic Zone (TVZ). Despite its significance, our understanding of volcanism during this period remains limited.

Major and trace element analysis of glass and new U-Pb zircon ages have confirmed a distal correlative of the ignimbrite, located near Lake Tutira, Hawkes Bay. This distal unit is termed the Hikuroa Pumice Member and is preserved within Mangaheia Group rocks of Nukumaruan age. A minimum eruptive volume of ~540 km^3 (DRE) has been estimated, which almost certainly makes the Waiteariki Ignimbrite the product of a caldera forming eruption. The source of this eruption is possibly located in the northern Mamaku Plateau, buried by widespread ignimbrites from the Okataina and Rotorua calderas. Situated at the southern end of an asymmetrical rifted graben, the newly defined Omanawa caldera lies between the Kaimai and Papamoa Ranges. North of the caldera, faulting has been episodic, and associated with periods of dome growth throughout the region. The western fault occurs along the Wairoa River, which has channelized pyroclastic density currents entering the Tauranga Region from the modern TVZ. Thus, we propose a shift in the extent of the early TVZ westward to include the Omanawa caldera and the eruption of the Waiteariki Ignimbrite. We further re-classify the Tauranga Volcanic Centre to include the Kaimai Volcanic Centre and the Omanawa caldera thus combining all volcanic deposits within the region aged between ~3.0 and 1.9 Ma. Further research will focus on new geochemical analyses of the Waiteariki Ignimbrite, to chemically characterise and determine pre-eruptive magmatic conditions that fueled the eruption of New Zealand’s earliest identified super-eruption.

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Biogeochemical cycling of the uranium isotope system down a permanently de-oxygenated fjord: Implications for de-oxygenation in the past oceans

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8C: Geochemistry, C3, November 25, 2020, 11:00 AM - 1:00 PM

Today, less than 0.3% of the marine environment is oxygen-depleted, however, studies are showing an expansion due to climate change. Therefore, it has now become essential to investigate how past de-oxygenated environments may help to infer how future expansion of low-oxygen areas will affect ocean-atmosphere regimes. Redox-sensitive metals and their isotope systems are used as tracers for investigating marine de-oxygenation throughout the Earth's past. However, in order to fully understand how these tracers can help predict the triggering, evolution and eventual re-stabilisation of past marine oxygen-deprived conditions, it is necessary to examine how redox-sensitive metals and their isotope systems behave in modern de-oxygenated environments.

The permanently de-oxygenated Framvaren Fjord, located in southwestern Norway, has an oxygen (O_2)/hydrogen sulphide (H_2S, indicative of an environment highly depleted in O_2) interface presently located within the photic zone at 18 ± 1 m depth, and the highest recorded concentrations of H_2S (6,000 µM) in a modern oxygen-deprived setting, 25 times greater than the Black Sea, the world's largest de-oxygenated marine environment. During a recent expedition, we collected a comprehensive suite of seawaters, porewaters and sediment samples from Framvaren Fjord, with the purpose of evaluating, with high depth resolution, the biogeochemical cycling of uranium (U), molybdenum (Mo), iron (Fe), zinc (Zn) and cadmium (Cd) and their isotope systems as they move between different chemically zoned regions of the water column.

Here, we present elemental concentration and U isotope datasets for various phases throughout Framvaren Fjord. The U isotope ratios show systematic changes down through the water column, as U is transferred from sources to sinks via intermediate pathways. These new data have important implications for reconstructions of past ocean de-oxygenation in relation to climate cycles and the evolution of life throughout Earth's history.

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The Priestley Glacier Deformation Experiment

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1C: Cryosphere, C3, November 23, 2020, 11:00 AM - 12:00 PM

Ice deformation plays a critical role in ice sheet and glacier flow. Flow laws used to model ice deformation come primarily from laboratory experiments. A laboratory experiment to simulate steady-state deformation needs a strain of at least 20%. Experiments that achieve this strain, using an isotropic starting material, are only realistic at rates that are two or more orders of magnitude faster than natural deformation rates. Using flow laws always requires extrapolation to lower strain rates and because of this it is important to identify natural systems that provide a test of that extrapolation.

Lateral shear zones at the margins of outlet glaciers and ice streams can be considered as natural experiments, in that it is possible to measure the strain rate and temperature and to characterise the ice anisotropy through seismology and radar methods. It is also possible to collect samples that allow ice physical properties to be measured and ice chemistry to be analysed. Critically difficult is the constraint of the stress tensor in the shear zone: modelling approaches and re-deformation experiments of samples both provide possible pathways to constraining components of the stress tensor.
We have completed two field seasons on the floating shear margin of the Priestley Glacier, that flows into the Nansen Ice shelf, Terra Nova Bay, Antarctica. We conducted field geophysics and collected cores to 58m depth in the shear zone. We will present preliminary results from sample analyses, seismic, pRES and surveying data. Combining the microstructural data from the ice cores with pRES and seismic data suggest that the shear margin has anisotropy consistent with shear constrained from the survey data at depths greater than ~100m, but rotated in a manner consistent with the shear zone vorticity in the upper 100m. The rotation probably reflects rigid block rotation between fractures.

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Airborne sea ice thickness measurements in the western Ross Sea

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2C: Cryosphere, C3, November 23, 2020, 1:30 PM - 3:30 PM

Antarctic sea ice is a stabilizing factor for global climate with unknown mass trend as thickness is particularly hard to measure. The western Ross Sea is an important region of sea ice formation; here, persistent offshore winds form so called coastal polynyas enabling continued freezing by pushing new ice out into the pack ice zone. By making use of airborne electromagnetic induction sounding (EM-bird) from a DC-3 fixed wing aircraft, we measured in 2017 the sea ice characteristics of the region over a distance of 800 km and find that pack ice is significantly thicker than commonly assumed. Using high-resolution satellite images and airborne photos from the same flight, we show that narrow deformational ridges can grow much more effectively compared to thermodynamic growth. Such deformed ice holds up to 80% of the ice mass in only 15% of the study area, which can get easily overlooked by low resolution satellite sensors. Our observations hold a link between wind driven ice dynamics and the ice mass exported from the western Ross Sea. We present an overview of our airborne measurements, which provide the first direct measurements of sea ice thickness in the western Ross Sea.

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Biological activity co-intensifies with rapid chemical weathering rates

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Measured rates of soil production are faster in the western Southern Alps of New Zealand than anywhere else on the planet, exceeding what our current geomorphic understanding allows for. One potential explanation for the presence of such rapid rates may be that biological processes help to facilitate soil production when it should otherwise be limited by rapid erosion and short soil residence times. To explore this potential explanation, we investigated the dynamics of soil formation along one rapidly forming (1.7 mm/year) New Zealand soil profile (0-30cm) by combining U-series chronometry, geochemical analyses, radiocarbon dating, microbial ecology, and soil organic carbon (SOC) chemical structure analysis.

Chemical weathering intensifies along this soil profile at 10cm. The 14C content of bulk SOC decreases with depth and, typically, the 14C content of chemically fractionated SOC pools follows the same trend. However, this trend is strongly disrupted at 10cm for the bioavailable SOC pool which has a mean residence time (MRT) on the order of decades while elsewhere in the soil, the MRT is on the order of centuries. This indicates that at 10 cm, bioavailable carbon is rapidly turning over, or cycling; a microbially driven process. Where carbon is rapidly cycling, SOC has elevated O-alkyl content indicating plant inputs of fresh energy-rich carbon.

Our results suggest that the shift in MRT at 10 cm indicates a rapid, biologically driven flux of nutrients potentially facilitated by symbioses between vegetation and soil microbes. This is corroborated by an observed flux of elements from the soil at rates well above what the soil's mineralogy should allow. This association between biotic activity and chemical weathering is suggestive biotic activity is, in part, responsible for the rapid soil production rates observed.

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Structurally-focused gold deposits in the Reefton Goldfield

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7C: Minerals, C3, November 25, 2020, 8:30 AM - 10:30 AM

A new geological map dataset of the Reefton Goldfield integrates much of the dense exploration and research data acquired over the last three decades, in addition to abundant historic information. The influence of structural geology on the early Paleozoic Greenland Group-hosted mineral deposits has long been recognised and the new map compilation confirms previous observations that these deposits occur within corridors of increased intensity and frequency of folding of the host rock. Examples of these folds have been well exposed during excavations associated with the Globe-Progress mine but for most the goldfield folds are inferred from measurement of bedding and folding-related cleavage in sporadic outcrops to determine fold limb facing and constrain location of fold axial traces. In places these data also indicate where cross faults have offset the folds.

Some of the older faults and shears associated with closely folded zones have been inferred to be conduits for mineralising fluids across the goldfield defined by deposit locations. The 1 Moz Globe-Progress mine gold deposit occurs in a local structural setting that is markedly different to typical Reefton Goldfield deposits and the geological map compilation does not reveal any similar structural settings elsewhere in the goldfield. The hypothesis that the Reefton Goldfield host rock is part of the detached upper plate of a metamorphic core complex implies the deeper parts of the original fluid plumbing systems have been displaced by the putative detachment shear zone and lie “up-fault” and not below the corridors of mineralisation expressed by the Reefton Goldfield gold occurrences. The rich Blackwater deposit demonstrates gold endowment persists to the Reefton Goldfield’s southern limit but the lack of Greenland Group exposure to the south and west is problematic for identifying a prospective, potentially offset corridor continuation.

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Panitahi: long-lived cone or one-hit wonder?

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Parasitic vent is a term to describe many satellite vents on the flanks of established stratovolcanoes, regardless of the magmatic relationship between the main and subsidiary eruption sites. At their simplest, parasitic vents are short-lived monogenetic eruption centers or, alternatively, they may develop into large composite cones; the exact delineation between the two is not always clear. Panitahi (Fanthams Peak) is one such composite cone located on the southeast flank of Mount Taranaki; five other parasitic vents on Taranaki were short-lived, monogenetic events. Panitahi has produced sub-plinian eruptions in its history, and understanding the nature of future eruptions is crucial for hazard assessment on the Taranaki Peninsula. A preliminary review of a range of stratovolcanoes and their respective parasitic cones may highlight the common features which could help to understand the magmatic connection and eruptive future of Panitahi. These features include the longevity of the parasitic vent, and the composition, relative timing of eruptions, and eruption styles of the parasitic and main vents. The results of this preliminary review suggest that the source of Panitahi magma is not directly linked to the summit magma chamber, but the magma for each may share a deeper source, suggesting that Panitahi may not be a continuation of the Taranaki Volcanic Lineament, but part of the discrete Taranaki volcanic center. As they do not share a shallow magma source, the distinct eruption regimes at Panitahi may not be the same as for the Taranaki summit vent. The eruption timeframe of Panitahi, from ~3000-1500 years, suggests a long-lived composite cone. However, this falls within the timeframe of one eruptive period, after which Panitahi could remain dormant if not rejuvenated by another batch of magma. Further investigation of Panitahi eruption products needs to be carried out to better understand its future eruption potential.

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Geochemistry of the 26th June 2019 eruption products from Ulawun volcano, Papua New Guinea

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7A: Volcanism, C1, November 25, 2020, 8:30 AM - 10:30 AM

This study summarises the first findings from the analyses of 9 samples from the last violent eruption of Ulawun volcano (Papua New Guinea) in late June 2019, which thinly covered large parts of New Britain with fine ash (>200 km wide). The samples cover erupted material of all 3 eruptive phases, the first 2 consisting mostly of ash and scoria while the last one mainly produced lava flows and minor scoria (all sampled at various distances from the crater). Grain size analyses show a minor to negligible contribution of "inhalable" ash particles (diameter <10µm) in the proximal and distal samples indicating very low respiratory hazard potential. The samples itself are tholeiitic basalts showing a more primitive shift compared to the older eruptions. The groundmass, which supports phenocrysts of plagioclase, olivine and 2-pyroxenes, is highly microcrystalline with a more basaltic-andesitic composition. Juvenile material can be distinguished between a "microvesicular" (<10-100µm) and a more coarsely vesicular (up to 200µm) texture, confirming volatile degassing and bubble coalescing. Phenocryst and microcrystal zonations occur increasingly in a sharp manner during the second eruptive phase indicating a possible rapid water exsolution at depth. The phenocrysts are further assumed to correspond to the deeper magmatic system with sharp overgrowths indicating little equilibration with a possible primitive magma infusion at shallow depth. First temperature and pressure calculations based on thermodynamic equilibria of measured phenocrysts and glass compositions indicate formations at over 1150°C and between 1.2 to 5 kbar for the first eruptive phase (4-18km depth). Current work is focused on more precise major and trace element measurements of the glass and phenocrysts of the eruptive phases 2 and 3 via EPMA and TIMS analyses, which then will be inputs for more temperature and pressure calculations and give isotopic insights into slab dynamics and contribution to the melt.

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Temporal changes in bedform morphology in shallow marine environments

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2A: Unravelling the Seascape, C1, November 23, 2020, 1:30 PM - 3:30 PM

The morphology, migration and orientation of bedforms can reveal important information about local and regional tidal forcing, sediment dynamics and boundary condition variations. Understanding bedform dynamics in complex hydrodynamic and morphological settings can provide insight on bed evolution and sediment transport processes, which are critical to addressing sediment management issues in areas with growing human impact, such as dredging, marine farms and the construction of offshore infrastructure.

In this study we investigate bedform geomorphology and evolution in relation with the hydrodynamics in Queen Charlotte Sound – Tōtaranui (QCS), north-east of the South Island, New Zealand. Throughout much of QCS the mean speed is low (~ 0.05 m/s), but increases to high mean speeds (> 1m/s) at the outermost part where it opens to the strong tidally-dominated Cook Strait.

We compare two multibeam bathymetry data sets acquired two years apart that targeted sediment waves in the high-energy outer QCS. We use observational data from deployed Acoustic Doppler Current Profilers over one year, providing current speed and direction time-series to explain the hydrodynamics and sedimentary processes involved in the sediment wave evolution. These data together with local and regional hydrodynamic modelling allowed a better understanding of the regional near-bottom conditions.

Results show that sediment wave morphology changes drastically over the 2-year time interval with wave crests increasing in complexity. We suggest that changes in sediment wave morphology likely occur where the tidal currents are the highest, enhancing strong near-bottom sediment resuspension and transport. These findings demonstrate the dynamic nature of this region over relatively short time scales, and provides new information on sedimentary processes related to tidal currents in New Zealand shallow marine environments.

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Predicting habitat suitability of filter-feeder communities in shallow marine environments, Queen Charlotte Sound-Tōtaranui and Tory Channel-Kura Te Au

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The distribution of benthic ecosystems is strongly influenced by the seabed geomorphology. The spatial variation of the benthic habitats is also affected by near-bottom currents, changes in light, nutrient concentration and food quality, associated with increases of turbidity within the water column. Detailed predictions of the geographic distribution of filter-feeder species and a better understanding of the physical processes influencing their spatial distribution is key for effective management and conservation.

To date, predictive distribution modelling has been derived from geomorphological parameters and usually using spatially limited observations. In this study, seabed mapping, oceanographic modelling, hydrographic records and biological observations are integrated to provide detailed prediction model of filter-feeder habitat distribution within Queen Charlotte Sound-Tōtaranui (QCS) and Tory Channel-Kura Te Au (TC), South Island, New Zealand.

We investigate the potential suitable habitat areas for filter-feeders in QCS and TC, in order to inform where habitat restoration management should focus efforts to recover communities such as the horse mussel (*Atrina zelandica*) or the green-lipped mussel (*Perna canaliculus*), both of which have high economic value in New Zealand.

Maximum Entropy predictive modelling was used to produce Habitat Suitability maps, using geomorphological parameters and seafloor classification information. Final Habitat Suitability maps incorporate oceanographic and sediment dynamic information and show that filter-feeder habitat distribution is highly-influenced by the hydrodynamics and sedimentary processes as well as the seafloor geomorphology. Filter-feeder communities inhabit quiescent areas, limited by depth, slope, sediment type, and coincide with regions with low near-bottom currents and low turbidity levels. Additionally, our results reveal the effects of coastal settlement and major marine traffic routes, limiting the suitable habitats to areas with lower human impact.

This study demonstrates that a multidisciplinary approach is crucial to better predict the spatial distribution of benthic communities, which is key to improve benthic habitat restoration and recovery assessments

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The last Gargantuan Penguin – an Eocene relict in the late Oligocene of the South Island, New Zealand?

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1A: Unravelling the Seascape, C1, November 23, 2020, 11:00 AM - 12:00 PM

Giant penguins, those larger than the Emperor Penguin, lived ~55 to 25 million years ago (Ma) before inexplicably going extinct. We report a new giant penguin from ~25 Ma, one of the youngest and largest recognised. The fossil was collected by keen amateur A.M.A. Engelbrecht, probably from the Waihao Valley, South Canterbury, and was donated to OUGD. Associated sediment indicates the fossil is from the transitional facies where Kokoamu Greensand grades up into Otekaike Limestone. A late Duntroonian age (mid Chattian, Late Oligocene) is inferred from stratigraphic placement and foraminiferal analysis. The specimen comprises paired humeri (upper wing bones); a complete left and bioeroded right. The left element is the largest penguin humerus reported from Oligocene or younger rocks (<34 Ma). At 182 mm in length, the bone is stout and longer than the gracile 176 mm humerus of the slightly geologically-older Kairuku grebneffi. Kairuku was the ultimate truly "giant" penguin genus previously reported, and probably stood at 1.28 m; Engelbrecht's penguin was probably slightly taller and heavier. Only a few fossils slightly larger than the Emperor Penguin have been recorded from younger strata.

Penguin humerus characteristics reveal evolutionary relationships. Some features show a superficial resemblance to Kairuku, however the enormous specimen has a large humeral head relative to humerus size, a very small tricipital fossa, and a sulcus across the ventral tubercle, all reminiscent of Late Eocene giant penguins such as Palaeeudyptes. These features indicate a basal species, remote from the rest of the concurrent penguin fauna. Unlike Engelbrecht's archaic giant, other coeval lineages were undergoing a rapid evolutionary shift in wing functional morphology. Driving forces are unclear, though it appears that the Palaeeudyptes-morphotype became poorly-suited to the changing oceans of the Late Oligocene. Other Oligocene fossils previously recorded as 'Palaeeudyptes-like' await review and comparison with this new giant.

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Spatial and temporal aspects of Deep-Seated Gravitational Slope Deformations on the South Island of New Zealand

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5B: Engineering Geology, C2, November 24, 2020, 11:00 AM - 1:00 PM

Deep-Seated Gravitational Slope Deformations (DSGSD) are the result of time-dependent mountain-scale sagging from rock mass relaxation and fatigue. DSGSD can affect the entire mountain slope from crest to toe and extend down to depths in excess of 300 m below the slope surface. Typically, DSGSD comprise a distinct extensional zone dominated by scarps near the crest of the mountain, and a compressional zone with a mantle of creeping rock/debris slides developed along the slope surface, grading with depth into deformed and highly fractured rock mass. Displacements associated with DSGSD creep at <10 mm per annum, but under certain triggering conditions DSGSD can cause large-scale fast-moving catastrophic landslides. Examples of catastrophic failures include the 1963 Vajont Landslide in Italy and the 1999 Chiu-fen-erh-shan landslide in Taiwan. Understanding the mechanisms of deformation associated with DSGSD are important for geohazard forecasting in land-use management plans and for establishing resilient communities.

In this presentation we demonstrate how the spatial and temporal distribution of the DSGSD on the South Island is strongly correlated with valley evolution within the schist belt. Recent developments in computational capabilities enabled the numerical evaluation of the extensive geotechnical database established during the 1980-1990 Clyde Power Project associated with the Clyde Dam in the Cromwell Gorge. Numerical simulation of the evolution of the Cromwell Gorge provides insight into the development of DSGSD in schist terrain. The key outcomes of the numerical models highlight the contributions of the following factors on rock mass deformation: 1) the anisotropic nature of schist; 2) role of rheological competency contrasts in lithological varieties of schist; 3) development of confined groundwater aquifers); and 4) far field stresses associated with the active oblique-compressional tectonic regime.

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A window on Zealandia: how can we unlock the scientific value of decades worth of offshore petroleum exploration?

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3C: Petroleum, C3, November 23, 2020, 4:00 PM - 5:30 PM

MBIE manages a significant petroleum collection which is the legacy of billions of dollars of exploration and production expenditure in NZ. These collections (which include several petabytes of technical data and several physical archives), have been gathered under NZ's resources and energy legislation. Arguably this collection provides one of the best windows we have into the nature and structure of offshore Zealandia.

I'll discuss what MBIE is doing to ensure that these important collections are used to inform effective decision making and innovative approaches to many of the future challenges facing NZ communities both within and outside of energy and resources, including natural hazard assessments, development of new energy resources and ongoing management of water resources.

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Characterization of surface alteration types on partially vegetated geothermal systems using hyperspectral and thermal remote sensing in combination with ground exploration techniques

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Hydrothermal systems develop secondary mineral assemblages due to rock and geothermal water interactions. Such minerals can be identified on surface and mapped using geological, geophysical and geochemical methods. Hyperspectral imaging and thermal remote sensing can complement geothermal exploration and monitoring to detect hydrothermal alteration and thermal anomalies of big areas, faster and cheaper than ground-based mapping alone. Here, we study Waiotapu Geothermal Field, located in the Taupo Volcanic Zone of New Zealand, to demonstrate the capability of such remote sensing tools for mapping surface hydrothermal alteration and geothermal features. The remote sensing data was supplemented with 74 soil/rock samples. These samples have been analysed using Visible Near Infrared (VNIR) and Shortwave Infrared (SWIR) spectroscopy, and element concentrations were measured by using Inductively coupled plasma mass spectrometry (ICP-MS). In addition, specific samples were imaged with a Scanning Electron Microscopy (SEM). From the combination of remote sensing data and ground samples, mineral alteration classification maps, thermal maps and their relationships to soil/rock chemical concentrations were derived. Spectral Angle Mapper (SAM) and Support Vector Machine (SVM) algorithms were used for generating classification maps and identifying three main soil/rock regions: silica-dominated, ignimbrite-dominated (host rock) and acid-sulphate alteration. Heat flow map based on thermal remote sensing shows a spatial heterogeneity among each class. Spectroscopy analysis indicate a mixture of the host rock with various levels of mineral alteration for most samples, with few samples representing the endmembers of the system. On the other hand, where the geothermal fluids have merged to surface, chemical concentrations show patterns of soil enriched with Ag, As, Au, S and Sb. The combination of these methods gives a new perspective of the hydrothermal system of Waiotapu Geothermal Field and confirms the benefits of remote sensing techniques for geothermal exploration.

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The Influence of Clay Mineral Properties on Expansion of Soils in Southland, New Zealand

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Agriculture in New Zealand's Southland region is an integral portion of the economy, reliant on soil health for sustainable farming practices and management of the region's freshwater resources. Some Southland soils expand in wet conditions, and are prone to macropore development or "cracking" in dry conditions. This is primarily caused by the high proportion of clay minerals present with water content dependent particle sizes. The resulting porosity can provide a passageway for water, pesticide, and fertilizer infiltration through the soil into the water table. Introduction of toxic agricultural chemicals into the soil and groundwater has adverse consequences for stock, crop, and human health, as groundwater is a major source of potable water in Southland. This project aims to determine the types and proportions of clay minerals in Southland soils and relate the clay mineralogy to the degree of microporosity and macroporosity in different soils when dry, and the degree of expansion when wet. Soil core samples have been extracted from 10 different soil types in Southland, primarily in the Central Plains area. The sites have been selected to allow for variations in climate, relief, and parent material. Analysis by X-ray diffraction (XRD) will identify and quantify their clay mineralogy. Analysis of properties such as cation exchange capacity, pH, grainsize, and carbon/nitrogen content will provide information on how clay mineralogy relates to compositional and textural features. The data produced by this project will contribute to Environment Southlands soils database and Manaaki Whenua's S-map by improving understanding of clay minerals in soil expansion and soil drainage processes. These databases supply information to nutrient management programs like Overseer to provide soil drainage parameters to model pollutant leaching. Ultimately, this research will relate geochemical soil properties to hydropedological processes that have a significant impact on freshwater quality and water management.

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Facies architecture of the NE sector of Lyttelton Volcano, Banks Peninsula

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7A: Volcanism, C1, November 25, 2020, 8:30 AM - 10:30 AM

Early erupted products from pyroclastic cones are often challenging to study due to burial by later products. The eroded flanks of the Lyttelton Volcano provide an excellent opportunity to investigate the internal architecture of a vent system with different lava flow morphologies, intrusive features and pyroclastic deposits. Here, we present detailed mapping and stratigraphic analysis of the northern sector of Lyttelton Volcano.

The area is composed by diverse small-volume pyroclastic cones (<1km3) aligned NE-SW, overlapped by thick sequences of lava-flows (>100m). The cone facies architecture is divided into four morphological gradational parts: (1)vent zone, (2)proximal, (3)medial, and (4)distal flanks. The vent zones consist of multiple intrusions associated with thick (>10m) agglutinate deposits of crystalline blocks, and fluidal bombs in an ash matrix. The proximal flank presents moderate slopes (20-30°) outward-dipping of the vent zone and comprise welded flattened and spheroidal bombs in a lapilli-ash matrix, as well as lava-like densely welded spatter-fed flows. Medial flank comprises dispersive bombs in lapilli-ash beds dipping 10-20° radiated away from the vent, while distal flank facies present better-sorted and well-bedded lapilli-ash deposits with rare bombs (<10cm). A series of epiclastic deposits overlie parts of the pyroclastic edifices indicating volcanic quiescence.

Following, a sequence of basaltic a`a flows overlies the pyroclastic cones. Individual flow thicknesses and flow length are in part controlled by the underlying topography. Flows of the outer slope of Lyttelton get thicker (5-15m) away from the vent. The final effusive stages are often characterised by trachytic flow (up to 25m thickness) with well-developed columnar joints and horizontal fractures followed by a sequence of basaltic pahoehoe to a`a phyric flows. The deposits examined in this study suggested an initial explosive fissure eruption to an effusive stage with the construction of larger edifices with voluminous and widespread lava flows.

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The ECLIPSE programme - reducing uncertainty around future unrest and eruption in the central Taupō Volcanic Zone through co-produced research

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

New Zealand's central North Island is home to the world's most frequently active system of rhyolitic calderas. The volcanic lakes, domes, and geothermal systems that stretch from Taupō to Tarawera are the surface expressions of this super-sized underground magma system. Every few years to decades, this caldera volcano system becomes restless, causing swarms of earthquakes, ground deformation and disturbance of hydrothermal systems. Every few hundred years (highly variable, but on average), this unrest leads to a volcanic eruption. These eruptions may be small or very large, and in the largest examples can have devastating impacts on people, the environment, and economy. Much more likely in the near future is unrest, yet there remain great uncertainties about the causes of unrest and the factors that make an unrest event occasionally lead into eruption. ECLIPSE (Eruption or Catastrophe: Learning to Implement Preparedness for future Supervolcano Eruptions) is a co-produced multi-institutional research programme funded by the New Zealand Ministry of Business, Industry and Employment (MBIE) Endeavour Research Programme (www.supervolcanoes.nz). Research in the ECLIPSE programme investigates the underground roots of the volcanic system to identify what conditions cause it to become restless or erupt and aims to better define the tipping point when unrest leads to eruption. Experimental and numerical modelling methods are being developed for consequent hazards and impacts in today's society. Through deep partnership with GeoNet, tangata whenua, the community (including schools) and emergency management groups, ECLIPSE research will also explore ways in which we can enhance resilience to these events. This poster shows the co-produced nature of the ECLIPSE programme through a visual mind-map of how our research links with stakeholders, parters, aligned programmes and research institutes.

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Melt inclusion and mineral chemistry recording magma evolution at Mt. Taranaki

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Melt inclusions provide a snapshot of magma evolution coincident with crystallization during magma storage and ascent, often lost during late homogenization of the final erupted magma. An important consideration of the potential behaviour of future volcanic eruptions is an understanding of how melt compositions evolve through time, and the changing proportions of magmatic components. Mt. Taranaki has a long history of erupting crystal-rich basaltic andesite to andesite tephra, ideally suited for melt inclusion investigations. This study utilizes tephras erupted over the past ~5300 yrs. Overall, melt inclusions, hosted in amphibole, clinopyroxene, and plagioclase, record a bimodal population with a mafic component between 50-56 wt% SiO_2 and a more silicic component from 61-72 wt% SiO_2. Over the investigated time interval melt compositions display systematic changes consistent with whole rock variation. The Manganui tephra, erupted ~2890 ybp, represents the most mafic composition investigated here. However, compositionally similar mafic melt inclusions are observed as a minor component in more evolved erupted magmas for the preceding ~2400 years, suggesting an episodic but persistent mafic input through time.

Melt thermobarometry, calculated from mineral-melt pairs ranges from ~835 to 1000°C and 2 to 6 kbar, suggesting relatively low-temperature, shallow conditions of magma crystallization. Plagioclase-melt hygrometry suggests exceptionally high magmatic water contents (up to 10 wt%), however water-by-difference suggests maximum water contents of up to ~6 wt%. Sulfur variations reflect the melt bimodality, with the mafic component recording variably degassed sulfur from ~3200 to 300 ppm, compared to the more silicic component with <700 ppm sulfur. Chlorine compositions overlap but the mafic component (1500-3000 ppm) is offset to lower Cl abundances than the silicic component (1500-4500 ppm). Overall, major element and volatile concentrations suggest a history of independent melt evolution and mixing, rather than a continuum of compositional evolution from mafic to silicic compositions.

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What lies beneath? A palynological and sedimentological history of the Wellington Basin (CBD) over the Late Pleistocene

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6C: Climate, C3, November 24, 2020, 2:30 PM - 4:30 PM

The 7.8 magnitude Kaikōura earthquake in 2006 lead to the demolition of 15 buildings along the Wellington waterfront, with insurance claims totalling to 1.84 billion NZD. The engineering and design of seismically resilient constructions that has taken place following this event requires extensive ground investigations. Here we present sediment core and borehole data retrieved from a redevelopment site in lower Thorndon, Wellington, and outline its recent and geological history.

Several ~50m cores at the site showed distinct changes in sediment ranging from alternations in gravel, sand, silt, shell rich mud, organic muds, and peat. The deepest core reached basement at 99 m, and has helped to constrain 3D engineering geological models of the region. We plan to undertake geochemical analysis (XRF and glass shard geochemistry) of the sediment on several cores, as well as radiocarbon dating, and plant micro and macro fossil extractions. This data will help to provide further insights into the tectonic, sea level and vegetation histories on the landscape over the Late Pleistocene in the Wellington Region.

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Murchison Basin sandstone provenance: early Miocene Pacific Plate uplift and erosion

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4C: Sediments, C3, November 24, 2020, 8:30 AM - 10:30 AM

Regional tectonics have been the principle driver of Cretaceous–Cenozoic sedimentary basin formation and evolution throughout Te Riu-a-Māui/Zealandia, reflected in widespread spatial and stratigraphic changes in basin-fill composition. The Murchison Basin is ideally placed to record Australian–Pacific plate boundary evolution through the middle–late Cenozoic and is the initial focus in our ongoing study of sediment provenance in the West Coast and Taranaki basins.

Sandstone compositions in the Murchison Basin range widely from litharenite to arkose but can be related to their stratigraphic and geographic positions within the basin. Late Eocene–early Miocene sandstones exposed near the western basin margin classify as lithic arkose or arkose, with mean normalised quartz and K-feldspar of ~45 and ~20%, respectively. Early Miocene rocks in the eastern basin contain relatively low quartz (~25%) and K-feldspar (~10%) and classify as lithic arkose or feldspathic litharenite. Overlying middle Miocene sandstones conform to these same spatial groupings, whereas late Miocene sandstones have intermediate compositions. Middle–late Miocene sandstones from the southern part of the basin are significantly more lithic-rich, classifying as feldspathic litharenite or litharenites, and contain low K-feldspar (<5%). Detrital zircon (DZ) age spectra also vary with stratigraphic and geographic position like the mineralogical compositions. Western basin sandstone DZ age spectra comprise dominant mid-Paleozoic or mid-Cretaceous and subordinate early Paleozoic components, suggesting a local plutonic and metasediment provenance. Early–Middle Permian and Jurassic–Early Cretaceous age components become increasingly dominant up-section in eastern sandstone DZ age spectra, suggesting additional sediment source(s) east of the basin in the outboard Median Batholith and/or Eastern Province terranes. Southern sandstone DZ age spectra are similar to the eastern basin time-equivalents with minor additional Middle–Late Permian and Triassic components and/or a lack of an Early Cretaceous component. We interpret these data to show early Miocene Pacific Plate exhumation at the plate boundary.

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Understanding Unrest in and around Lake Tāupo through Serious Gaming

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8A: Geo-Teaching & Practice, C1, November 25, 2020, 11:00 AM - 1:00 PM

The Tāupo Volcanic Zone is an active center of geologic unrest in New Zealand [Illsey-Kemp et al., 2019]. Volcano risk awareness depends on how people respond to physical processes like the release of gases for preparedness and strategic mitigation [Campell et al., 2019]. An understanding of the balance between magmatic processes and human activity can be useful in risk mitigation in various unrest scenarios but remains challenging. Gamifying these concepts however can result in authentic engagement and improve volcano risk literacy [Mani, Cole & Stewart, 2016]. In this study, a serious game Magma Pop, developed at the University of Canterbury through collaboration between the Schools of Product Design, Earth and Environment, and Teacher Education is used to assess if concepts related to geology (like specific mineral formula; magma-chamber cooling) can be reinforced through serious gaming.

A functional prototype of Magma Pop was tested in an intermediate-level geochemistry, igneous petrology, and volcanology classroom for 30 minutes. Interested students (n=27) were then approached for semi-structured focus group (n=5-7) interviews. Students identified that Magma Pop can be useful for learning mineral formulae, and suggested that: (i) opportunities for critical reflections through the inclusion of characters or pop up messages can enhance active learning and (ii) a game mechanic to collect minerals at the bottom of the chamber, earn rewards and ward-off situation-specific consequences, could be a meaningful extension of the serious game.

In future iterations, Magma-Pop will extend the use of engaging game elements such as characters, storylines, and reward systems. It will also include Māori artwork to provide a situated and meaningful learning experience. This will allow players to explore the consequences of unrest in the magmatic system around Lake Tāupo.

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Deep-marine ichnostructures and their relevance as paleoenvironmental proxies: preliminary results.

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

In recent years there has been an increasing interest in deep-marine environments, particularly in geobiology. Ichnology, the study of trace fossils, investigates the interactions between organisms and substrates, which provides information on paleoenvironmental conditions, such as substrate cohesivity, sedimentation rate, and changes in the sediment oxygen conditions.

In particular, this study targets biogenic structures from core samples of Hole 1520-D (3,200 m depth), drilled by the International Ocean Discovery Program (IODP) Project 375 expedition, on the Hikurangi subduction margin off eastern New Zealand. The main goal of Project 375 is to understand slow-slip events. The studied core is rich in biogenic sedimentary structures; thus, a biogenic-sedimentologic approach may provide new insights into the paleoenvironmental changes that took place during sedimentation. Specifically relating biogenic emplacement processes with the physical sedimentary structures will provide a better comprehension of the recorded bio-physical paleoevents, which is the main focus of this research project.

Furthermore, new technology has provided us with novel tools and methods that are allowing us to improve our understanding of deep-marine biogenic structures, such as being able to create three-dimensional reconstructions of core sediments, in order to understand the colonization emplacement processes associated with tectonic and volcanic events. This approach will be utilised to make outcrop comparisons, based on ichnostructural analysis, to refine paleoenvironmental interpretations.

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Is crustal AFC responsible for felsic magma generation in the Taupo Volcanic Zone (TVZ)? Evaluating the major oxide, trace element and isotopic evidence

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The Taupo Volcanic Zone (TVZ) is an area of subduction zone volcanism in a rifted arc, active since 2 Ma, dominated by high-volume high-silica eruptions from large caldera-systems, and has one of the highest present-day magma production rates on Earth. The general model used to explain the geochemical signature of the TVZ consists of assimilation and fractional crystallization (AFC) with Torlesse greywacke crust as an assimilant. Chemically diverse and geographically distributed samples from the TVZ were analysed for major oxides, trace element concentrations and strontium (Sr) isotopic composition ($^{87}Sr/^{86}Sr$). Major oxide AFC models (MELTS and Magma Chamber Simulator) show that at low pressures (1.5 kbar) and low water contents (0.5-1.5 wt% H_2O), the TVZ compositional range from basalt to rhyolite can be theoretically reproduced. However, these models require high degrees of fractional crystallisation (90%) and assimilation (60%) and hence an excessive amount of mafic magma to generate the large volumes of felsic extrusions and intrusive bodies known to be present in the TVZ. This makes a pure AFC process highly unlikely for the origin of intermediate and felsic rocks. Additionally, AFC models fail to explain the Sr isotopic signature of several mafic and intermediate samples that instead, coupled with major oxides, suggest a heterogeneous mantle source. Processes that may modify the Sr isotopic signature of the mantle is addition of different amounts of sediments from the subduction zone and subduction erosion (*e.g.* Torlesse crust recycled via forearc erosion), which will be discussed.

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Risk reduction through land-use planning for natural hazards

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3B: Hazards Symposium, C2, November 23, 2020, 4:00 PM – 5:30 PM

Land use planning plays a key role in reducing risks from natural hazards, including climate change adaptation. Wendy Saunders will provide an overview of the wider risk reduction system, options to use land use planning as a risk reduction tool, and discuss the future opportunities to strengthen land use planning policies.

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Measuring the relation between changes in seismic wave speeds, geodetic displacements, and water well levels in the Wellington region

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Seismic wave speeds, water bore levels and GNSS station locations all changed at the time of the 2016 Kaikōura earthquake. We have begun a project to determine the relation between these types of changes by re-examining data from permanent GeoNet stations and by deploying temporary seismometers at sites of water bores that were evaluated for changes due to the Kaikōura earthquake. We have deployed 10 seismometers. Three started in March just before the Covid-19 lockdown, and the rest were installed in July. For the permanent data on the South Island, using the station-to-station cross-correlation technique we have found drops in velocity at the time of the Kaikōura earthquake ranging from 0-0.2% for paths between stations that had a natural period of 2 Hz, and an average of 0.15% for paths between broadband stations. The velocities at the broadband stations also dropped about 0.1% over the time of the Cook Strait earthquakes. Using cross-component correlations on stations in the Wellington region, we measure velocity drops up to 0.5% on southwestern stations BHW and WEL at the time of the Kaikoura earthquake for the frequency range 0.1-1 Hz. These drops are not as strong on stations located further north, with the largest amplitude drop of about 0.25% on station KIW at Kāpiti Island and OGWZ just northeast of KIW. We have begun processing the first few months of the temporary data and expect to be able to compare the results to the water wells by the time of the conference.

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An Unusual Fossil Duck from the Greta Formation of North Canterbury gives an insight into the Fauna of late Miocene Coastal New Zealand.

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1A: Unravelling the Seascape, C1, November 23, 2020, 11:00 AM - 12:00 PM

We describe a partial skeleton of a medium-sized duck from a dense carbonate concretion that was found weathered on the beach beside the Motunau River mouth in North Canterbury, on the east coast of the South Island of New Zealand. These concretions are formed in the Greta Formation (late Miocene to mid-Pliocene) and based on the molluscan and decapod assemblages and the available sedimentological evidence, Feldman et al. (2006) concluded that the fauna within the concretions inhabited an offshore, outer-shelf environment, probably at least 200 m in depth. The bulk of the fossil vertebrates that have previously been reported are not epipelagic or epibenthic and therefore probably represent transported corpses.
Osteology of this well preserved although fragmentary specimen indicates that this new taxon belongs to the Anatidae that exhibits several features that may indicate adaptation to a marine or coastal environment.
The presence of an apparently marine duck in the Mio-Pliocene of New Zealand gives insights into the Miocene New Zealand coastal ecosystem. This fossil also provides more evidence about the construction of New Zealand’s Recent avifauna, suggesting that the Mio-Pliocene period was crucially important in developing an endemic, but Australian based fauna.

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Development of a Bayesian Event Tree for Short-term Eruption Onset Forecasting at Taupō Volcano

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Taupō volcano, within the Central Taupō Volcanic Zone, is a silicic caldera volcano that has experienced both relatively small and very large eruptions. It is home to the world's most recent super-eruption, the 26.5ka Oruanui Eruption, and one of the most violent eruptions in the last 5000 years, the 232AD Taupō eruption. There have been at least 27 eruptions of VEI 3-6 at Taupō since 20.5ka, making Taupō volcano one of the most frequently active silicic volcanoes on earth. Considering there are 39,300 people living within 50km of Taupō volcano and 3.4 million within 250km, there is a high volcanic hazard exposure and a clear requirement to manage the volcanic risk. This is complicated by observations that Taupō volcano has experienced 17 recorded periods of unrest in the last 140 years, none which have led to eruption. There is little understanding about volcanic unrest at Taupō, particularly the implications for eruption forecasting.

Therefore, improved eruption forecasting tools would be particularly useful to help inform risk management for a future crisis at Taupō. One possible approach is a Bayesian event tree (BET), which provides a structured approach to answer how likely it is that an eruption will occur, given observed unrest. Such BETs aids scientists, decision makers, and emergency management in understanding the dynamics of an unrest episode, and hence the potential risk.

In this research, a BET will be developed specifically for Taupō Volcano for short term eruption forecasting using the Bayesian Event Tree for Eruption Forecasting (BET_EF) approach. The BET will be developed from analogue data augmented as necessary by expert elicitation. The resulting BET_EF model will be validated by running through each historic unrest period at Taupō Volcano.

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New Zealand’s mantle peridotite and serpentinite

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4A: Volcanism, C1, November 24, 2020, 8:30 AM - 10:30 AM

New Zealand has a remarkably large number of exhumed mantle occurrences for a small exposed landmass. Since the last regional syntheses of peridotite (1987) and serpentinite (1966), new locations have been discovered and abundant geochemical and isotopic data have been acquired. Mantle peridotite is known from nine massifs along the base of the Dun Mountain Ophiolite Belt (DMOB), xenoliths in volcanic fields in at least 75 localities, and as one 15 km-long orogenic body in Fiordland. In these occurrences, spinel peridotite is abundant, plagioclase peridotite is restricted to the DMOB, and garnet peridotite is absent. The xenoliths and orogenic peridotites represent exhumed lower portions of Phanerozoic continental lithosphere, whereas the ophiolites represent accreted oceanic lithosphere. Hydrated peridotite (serpentinite) is even more widespread, and extensively developed in three ophiolites (Dun Mountain, Northland and Pounamu). Serpentinite is also associated with some altered igneous ultramafic and mafic rocks. The recently acquired data have led to discoveries including the occurrence of Archean and Proterozoic mantle lithosphere under Zealandia, the presence of regional-scale fertile and refractory mantle lithosphere domains, isotopic similarities between metasomatised mantle and intraplate volcanic magmas, and characterisation of serpentinite during faulting.
Scott J.M. (2020) An updated catalogue of New Zealand’s mantle peridotite and serpentinite. New Zealand Journal of Geology and Geophysics, in press.

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Lessons learned in building virtual fieldtrip for undergraduate Geology students

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9A: Geo-Teaching & Practice, C1, November 25, 2020, 2:30 PM - 3:30 PM

A major challenge of the COVID lockdown was working out how to give undergraduate students an opportunity to undertake the compulsory field-mapping classes that their geology degree requires. Each year, Otago geology students spend 5 days in the Borland Road area on the margin of Fiordland examining a superb geological sequence that extends from gneisses and plutonic rocks in the west into the overlying sedimentary Waiau Basin to the east. In the week before lockdown, we visited, videoed and photographed the outcrops and incorporated this information into interactive 3D web-based story maps. We then ran the field school as a 4 day virtual fieldtrip that visited each of the usual stops, and we built exercises for student to do in groups. Some key lessons learned are that it is essential to give the students something to do at each “outcrop”, working in break-out groups was quite effective although too many groups leads to confusion, and perhaps most importantly is that an online fieldtrip – whilst no substitute for the real thing – can at least give a reasonable impression of field geology.

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Natural rehabilitation of arsenic-rich historic tailings at the Alexander mine, Reefton, New Zealand

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Tailings resulting from orogenic gold processing commonly form arsenic (As)-enriched environments. A result of this is that they draw environmental attention in modern gold mining settings and significant effort in long-term rehabilitation. The Alexander River mine processing site in the Reefton area of Westland provides an opportunity to examine the natural rehabilitation of As-enriched tailings that have been left undisturbed for >70 years in a high rainfall environment. These historic tailings comprise a ~1 m thick package of delicately laminated sediments that accumulated on a terrace downstream of the gold extraction plant. The tailings sediments are As-rich (up to 5000 mg/kg) due to relict arsenopyrite and As-bearing pyrite. Diagenetic Ca-Fe arsenate (yukonite) and As-bearing iron oxyhydroxide have formed during localised oxidation. There was sufficient calcite in the tailings to maintain circumneutral pH in the tailings despite sulphide oxidation. The historic tailing impoundment is now covered by grass, ferns and shrubs, with beech and rimu forest covering several metres at the margins. Leaf analyses indicate that the vegetation is absorbing only minor As, and the As-rich tailings substrate has not halted vegetation re-colonisation and natural remediation.

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Ecosystem Vulnerability to Hydrate Mining: Tracking the sphere of influence of methane seeps

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3A: Unravelling the Seascape, C1, November 23, 2020, 4:00 PM - 5:30 PM

As global interest in commercial extraction of methane from gas hydrates intensifies there is an urgent need to understand what implications this may have for surrounding ecosystems. The Hikurangi Margin offshore of Aotearoa/New Zealand is an area with both the geologic potential for hydrate mining and economic interest in such activity. HYDEE (Gas Hydrates: Economic Opportunities and Environmental Implications) is a multi-disciplinary research programme designed to address a number of questions, including: Would hydrocarbon production from gas hydrates significantly impact seafloor stability, ecological processes, and ocean biogeochemistry? Here, we will link observations of seep ecology and biogeochemistry with subsurface geology at three distinct seep sites on the Hikurangi Margin. We will incorporate data collected on a series of multidisciplinary cruises to explore how hydrate mining may impact the biological diversity and ecosystem services of New Zealand. Through this, we will pinpoint vulnerabilities to the surface and subsurface disturbances that are associated with hydrate mining, while also constructing a framework of the influence of active methane seeps on the structure and function of the surrounding environment.

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New Zealand Community Fault Model

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5B: Engineering Geology, C2, November 24, 2020, 11:00 AM - 1:00 PM

There has been a long-identified need in New Zealand for a community developed fault model that is accessible and available to all. GNS Science has long maintained products such as the Active Fault Database, related Active Fault Model, and QMAP, which provide a significant amount of basic fault information. However, a three-dimensional fault model that represents New Zealand's best scientific knowledge that can easily be used or adapted for multiple scientific and practical uses is not presently available.

The New Zealand Community Fault Model (NZCFM) will serve as a unified and foundational resource for many societally important applications such as the New Zealand National Seismic Hazard model, Resilience to Natures Challenges Earthquake and Tsunami programme, physics-based fault systems modelling, earthquake ground-motion simulations, and tsunami hazard evaluation.

The NZCFM is an object-oriented, three-dimensional representation of active faults in New Zealand and adjacent offshore regions. The model presently incorporates more than 600 objects (i.e., faults), which include triangulated surface representations of those faults and associated meta-data such as slip rate and movement type. The NZCFM faults are defined based on surface traces, seismicity, seismic reflection profiles, wells, and geologic cross sections following methodologies developed by the Southern California Earthquake Center.

Precise fault system geometries better define earthquake source parameters, such as the fault surface area and orientation, and have been shown to have an important influence on slip rate estimates derived from geodetic constraints and on earthquake rupture dynamics.

We present an initial model developed from an existing 2D fault model published in 2014, the formulation, parameterisation and documentation of that model in 3D; and the availability of that model in a readily accessible form(s) to support and facilitate multiple realisations and varied applications.

More information about this project can be found at: https://www.gns.cri.nz/Home/Our-Science/Natural-Hazards-and-Risks/Earthquakes/Community-Fault-Model

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Shaky volcanology: how do bubbles respond to seismic waves in the laboratory?

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4A: Volcanism, C1, November 24, 2020, 8:30 AM - 10:30 AM

Characterizing how seismic waves affect magma bodies is crucial in order to explain how earthquakes can trigger volcanic eruptions. In particular, the way bubbles respond to shaking is poorly understood. An investigation of bubble dynamics during pressure oscillations needs to account for (a) the pressure-dependent solubility and diffusivity of water in magma, and (b) the complex non-Newtonian and water-dependent rheology of silicate melts. These challenges have been overcome by running experiments at natural conditions. We conducted a series of high-temperature (900-990°C) experiments using natural obsidian (75 wt% SiO_2) contained in cylindrical alumina crucibles. We simulated the passage of seismic waves by oscillating the pressure with a piston. Sample volume was continuously monitored while bubble texture and volatile concentrations were later observed using scanning electron microscopy (SEM) and Fourier-transform infrared spectroscopy (FTIR), respectively. We observed no evidence of seismically-induced bubble nucleation. However, preliminary results suggest that shaking facilitates degassing via diffusion. Therefore, shaken bubbles may provide an explanation for seismically-triggered unrest, a ubiquitously reported yet poorly explained phenomenon. The implications of our experiments are particularly relevant for persistently active volcanic centres located in regions prone to large earthquakes, such as the Taupo Volcanic Zone.

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Microstructural characteristics of paired harzburgite and dunite bands in the Red Hills Massif, Dun Mountain Ophiolite

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

To determine how microstructurally and compositionally distinct materials behave under the same forcing/boundary conditions, we have examined the microstructural evolution of six "paired" banded harzburgite and dunite samples from the Dunn Mountain ophiolite belt in New Zealand. We find that, in each pair, dunite generally has larger grain size, stronger CPOs (crystallographic preferred orientations), higher seismic anisotropy and smaller grain aspect ratios than harzburgite. The samples display five different types of olivine CPOs (A, C-E and AG-types of Jung & Karato, 2001). Most harzburgites have A-type CPOs, but AG- and E-type CPOs are observed in thicker harzburgite bands (>5 cm). The other types of CPOs are restricted to dunite bands. There is a systematic relationship of CPOs to other microstructures in all pairs. D/E-type samples typically have the largest grain sizes, highest seismic anisotropies and smallest grain aspect ratios. The banded harzburgite and dunite is generated by partial melting during ductile shearing, during which orthopyroxene is removed from harzburgites by passing melt, leaving dunite. This process induces a transition from A-type to either C-, E- or AG-type CPOs in (thicker) dunite bands. We infer that olivine grains in dunite bands grow more rapidly than in adjacent harzburgite due to the influence of the melt, and hypothesise that D-type CPOs form in dunite bands because orthopyroxene restricts recovery by grain boundary migration less than it does in harzburgites. Such processes make it possible to generate multiple olivine CPOs from the same kinematics within in a single deformation event.

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How have Hikurangi margin gravity flow processes evolved from the Pleistocene to recent? Insights from IODP expedition 375, Hole U1520.

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Gravity flow processes are one of the most significant mechanisms of sediment transport and deposition in submarine environments. The characteristics of their deposits can provide valuable records of how sedimentary systems vary over time. A >1,000 m-thick sediment record was acquired in 2018 from the northern Hikurangi Trough as part of the International Ocean Discovery Program (IODP) Expedition 375. The upper ~106 m of this record provides a high-resolution record of a turbidite emplacement associated with glacial-interglacial climate cyclicity. An integrated investigation into how this submarine environment has changed in the past ~40 kyr has been conducted using U1520D core data and 2D seismic-reflection data . As part of this study, an analysis was performed on several seismic surveys, obtained from the northern Hikurangi Margin region, to identify key seismic horizons, seismic facies, and notable geomorphic features (such as buried channels and sediment waves). These features were correlated with observations from the core material to provide a spatiotemporal context to a sedimentary facies model. This facies model has been constructed based on the geochemical, physical and sedimentological properties of the core and complements the interpretations of the processes responsible for the features observed within the seismic dataset. Radiocarbon, tephra, and oxygen isotope dating have been used to create an age model that provides a temporal framework to the seismic and sedimentological datasets. Prior studies of the sedimentary successions in the Hikurangi Trough have either been limited to short cores that have not penetrated glacial lowstand or have relied entirely on seismic interpretations, so the correlation of seismic data with the Site U1520 sedimentary record provides a more in-depth understanding of how siliciclastic sedimentary processes have changed.

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Quaternary evolution of one of the world's largest coastal dune systems, Fraser Island and Cooloola, SE Queensland, Australia

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5C: Climate, C3, November 24, 2020, 11:00 AM - 1:00 PM

Fraser Island (K'gari) and the adjacent Cooloola Sand Mass (CSM) in SE Queensland, Australia, form one of the largest and most complete sequences of coastal dunes on the planet. Up to eight major phases of dune formation extending from the mid-Pleistocene to the present are preserved. Here we present the first pre-Holocene chronology from Fraser Island and in combination with chronologies from the CSM, we demonstrate that the dunefields extend back more than 700,000 years. We examine the causes of formation of the dunefields, including the trigger for the original inception and the relationship of dune formation to sea-level change. A persistent theme in the Australian literature is last glacial maximum (LGM) aridity and the activation of dunes during stadials. For this coastal sub-tropical region, however, the evidence suggests that all major phases of dune formation occurred on intermediate to high sea-levels.

We also highlight the formation of extensive and persistent lakes on K'gari at MIS 5e and examine the implications for long-term climate, particularly moisture balance in the coastal sub-tropics of SE Queensland. We will contextualise these observations in the light of recent paleoenvironmental work in this region. Finally, we speculate on implications of the work for long-term human habitation of K'gari.

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Weakening of Alpine Fault rocks by passing elastic waves

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The granular and cracked mircostructure of rocks gives rise to a range of unusual nonlinear phenomena. For example, many studies have shown that a rock can weaken when large-amplitude seismic waves pass through it. Additionally, rocks can take minutes to days to recover their original strength after such a perturbation. This nonlinear behaviour may have practical implications for processes in Earth's crust. If passing seismic waves from one earthquake weaken the rocks in a distant fault, a second earthquake may be triggered. In this work, we investigate how rocks from the Alpine Fault weaken when subjected to elastic waves with increasing energy. We compare the weakening of rocks with increasing proximity to the fault plane, including schists, mylonites, and cataclasites from the DFDP boreholes. Elastic waves are generated and recorded in the rock samples using lasers. Additionally, we perform these measurements inside a pressure vessel where we can control the ambient pressure and temperature up to 40 MPa and 200°C, respectively. This is important if we are to realistically evaluate the weakening of Alpine Fault rocks in their in situ environment. Initial results show that the shear modulus of the cataclasites decreases by several percent under transient strains typical of strong seismic waves. The magnitude of the weakening decreases both with depth and distance away from the fault core. Through our experiments, we can better understand the mechanisms which contribute to nonlinear behavior in fault rocks and assess the potential for these rocks to influence dynamic earthquake triggering.

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Multi-proxy evidence for a millennial expansion of the South Pacific Gyre driven by ENSO/SAM interactions

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9C: Geochemistry, C3, November 25, 2020, 2:30 PM - 3:30 PM

The South Pacific Gyre (SPG) is the largest gyre on Earth. It modulates Pacific climate by distributing warm, subtropical waters southwards along its western limb and returning cool, subpolar waters northwards along its eastern limb. In recent decades, acceleration of the SPG's western boundary currents have increased temperatures in the SW Pacific and altered macronutrient distributions and impacted marine ecology. Global warming is assumed to be the driver; however, recent paleoceanographic records suggest that the Gyre may have experienced similar changes in past millennia.

Here we investigate a possible SPG enhancement between 2000-3000BP by reconstructing circulation and nutrients using deep-sea black corals from New Zealand and the Tasman Sea. Our corals reveal a reduced radiocarbon reservoir age (ΔR) and enriched nitrogen isotope values ($\delta^{15}N$) between 2000-3000BP. This is consistent with a greater southward penetration of central Gyre waters which are characterized by low ΔR and settling organic matter with a high $\delta^{15}N$. We infer that this resulted from a strengthening of overall Gyre circulation.

This thousand-year interval of stronger SPG circulation corresponds to a period where El Niño-Southern Oscillation (ENSO) and the Southern Annular Mode (SAM) are coupled. Both ENSO and SAM modulate the strength of different component currents of the SPG. ENSO affects the South Equatorial Current and East Australian Current (EAC) while SAM affects the EAC, EAC-Extension and Tasman Front. We therefore propose that a coupling between ENSO/SAM drove a strengthening and expansion of the SPG that resembles the Gyre intensification observed in the present day.

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How much co-seismic strain is needed for a slope to transition from incipient landsliding to debris avalanching, with reference to the Mw7.8 2016 Kaikōura earthquake

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Understanding the processes governing the transition from incipient slope deformation to catastrophic failure forms a key component of landslide hazard and risk analysis. The 2016 Mw 7.8 Kaikōura earthquake triggered ~30,000 landslides, most of which were avalanches in soil and rock, with less frequent translational and rotational slides mainly in rock. In addition, the strong earthquake shaking caused large areas of ground to crack. Most of these cracks are thought to represent incipient landslides, as many were located upslope of the soil and rock avalanche source areas and around the flanks of the rock slides. In this paper we investigate how much strain is needed to transition a slope from being intact to failing as a debris avalanche.
To do this, we used remote sensing and field measurements of permanent ground deformation at various stages of failure – from intact to incipient landsliding to avalanching – caused by the Kaikōura earthquake. We use these to estimate the strains required for a slope to transition from incipient sliding/deformation to catastrophic failure e.g. avalanching. Based on the evaluation of ground displacement vectors and geomorphologic mapping, one-dimensional strain is calculated along longitudinal sections of the slope. Failure mechanisms and patterns of surface strain accumulation are assessed for each slope and landslide in a range of different terrains and geology. Strain thresholds marking the transition between incipient avalanching and avalanching, and incipient sliding, sliding and avalanching are compared between different sites and evaluated based on the characteristics of each site. Based on this analysis, a preliminary relationship between the probability of co-seismic debris avalanche initiation as a function of strain accumulation has been estimated, which could provide new ways to model co-seismic slope failures in future earthquakes.

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A tale of two converging blocks: A new model of Neogene tectonic development for the Lake Kaniere - Lake Brunner area of the West Coast

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Field observations and kinematic data support the presence of a north-striking sinistral strike-slip fault present beneath the eastern shore of Lake Kaniere on the West Coast. These data, along with further kinematic observations made across the area of exposed basement rocks, west of the Alpine Fault between Rotomanu and Lake Kaniere, show that the Neogene tectonic development is more complex than the previously supposed singular low-angle range-front thrust. I propose a new tectonic model of two convergent blocks – the southern Tuhua-Turiwhate block which has moved north, and the northern Hohonu-Te Kinga Block which has moved east. These blocks have converged through over-thrusting onto an area of anomalous self-propelled Neogene basement subsidence centred beneath the Taramakau River, which is also coincident with the Kumara Magnetic Anomaly. The lamprophyric Hohonu Dyke Swarm (HDS) and A-type French Creek Granite (FCG), both found in the Hohonu Range, are co-genetic, and together imply the presence of a nearby large mafic magmatic source body. If this implied magmatic body is responsible for producing the adjacent Kumara Magnetic Anomaly, and as modelling suggests, it sub-crops broadly across the Grey Valley Trough, then my tectonic model explains why only peripheral magmatic features (the HDS and FCG) are present where basement rocks are exposed immediately to the east.

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The Forgotten Variable: Effects of sample preparation on geochemistry of invertebrate skeletal carbonate

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9C: Geochemistry, C3, November 25, 2020, 2:30 PM - 3:30 PM

So you've collected a marine skeletal carbonate sample for geochemical analysis. What do you do with it? Standard sample preparation often includes cleaning, bleaching, preservation and storage techniques that may affect temperate invertebrate skeletal carbonate composition and integrity. Here we report on a series of interlinked studies on sample preparation. Among the key results: cleaning with tap or deionised water has little detectable effect on sample composition and integrity. Bleaching with sodium hypochlorite, especially at low concentrations and for short times, results in no change in mineralogy or stable isotopes. High concentrations of bleach, and oxidation using hydrogen peroxide, result in sample dissolution and the leaching of Mg from high-Mg samples and a significant effect on stable isotope concentration. Chemical removal of organic material is often not necessary. Ultrasonication of samples results in loss of Mg and skeletal material generally, especially from high-Mg specimens. The combination of ultrasound with bleaching (a common shortcut) is even worse. Roasting of specimens to remove organic carbon causes dramatic changes in composition and cannot be recommended. Ongoing studies on the effect of storage in various preservatives and conditions are underway.
In short, sample preparation and storage can have considerable effect on subsequent chemical investigations, and must form part of research planning as well as sample labelling.

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Intraplate basaltic volcanism in northern New Zealand: paradigms and processes

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

A major period of subduction-related volcanism in northern New Zealand began about 20 million years ago; its locus of activity migrated southward during the late Cenozoic in response to changes in convergence between the Australian and Pacific tectonic plates. As the volcanic arc migrated, spatially and chemically discrete fields of small-scale basaltic volcanoes were established behind the active subduction system. These volcanic systems display geochemical characteristics that reveal patterns of mantle behaviour linked to the rapidly evolving plate tectonic environment of Zealandia. Two Northland volcano fields initiated 8 million years ago have been active into recent times; their chemical compositions reflect partial melting of shallow mantle and their spatial relationships an essentially static source. In contrast four Auckland fields are dominated by alkalic magmas that ascended rapidly from garnet-bearing asthenospheric sources in a northward migrating pattern of discrete temporal episodes (~1 ma duration) since 3 Ma. The Northland fields were sourced in mantle that became coupled to the lithosphere, the southern fields reflect independent actively rising asthenospheric mini-plumes linked to mantle convection associated with the developing subduction system beneath the central North Island. This model envisages volcanic fields as geochemical systems, each with discrete spatial/temporal space. The implications are that beneath the northern North Island during Pliocene to Recent times discrete magma sources existed within the upper mantle as partially molten crystal/liquid mushes capable of yielding a compositional range of magmas at temporally variable intervals. The model supports the paradigm that the rise of individual magma batches to create a volcano at the Earth's surface is triggered by far field tectonic events rather than by a discrete partial melting episode beneath the active volcanic field.

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Rhyolite magma factory in the central Taupō Volcanic Zone: magma extraction depths for dome eruptions complementing structural models of the crust

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5A: Volcanism, C1, November 24, 2020, 11:00 AM - 1:00 PM

The central Taupō Volcanic Zone (TVZ) experienced a period of heightened rhyolitic volcanism between c. 350 ka and c. 240 ka (an "ignimbrite flare-up") with >3000 km^3 of magma erupted during seven caldera-forming events. Previous geobarometry calculations have shown that the caldera-forming magmas were stored over a wide depth range in the mid to upper crust (50–250 MPa, ~2–9 km), with the later eruptions becoming progressively shallower. We investigate the much smaller, but more frequent, rhyolite dome-forming eruptions that happened throughout the flare-up, as an initial assessment of the rhyolite magma factory in between the major caldera-forming events.

We compiled literature whole-rock compositions (257 samples) of rhyolitic domes erupted throughout the central TVZ in the period pre-, syn-, and post-flare-up (c. 600 ka to c. 200 ka). For each composition we used rhyolite-MELTS (following Gualda et al., 2019, EPSL, 522, 118) to calculate the pressure, correlated to depth, from which the rhyolites were extracted.

Our magma extraction pressures show a strong agreement with geophysical models of the vertical structure of the TVZ crust. The mode extraction pressure is between 250 and 350 MPa (~9–13 km), coinciding with a zone of mush cumulates at depths between 10 and 15 km. There is a second mode at 125 – 175 MPa (~5–7 km) which is the level of rhyolite magma storage revealed in previous geobarometry studies and indicates an ephemeral holding zone of shallow magmas at the brittle-ductile boundary of the crust. Single caldera complexes show a wide range of rhyolite extraction pressures (90–490 MPa, ~3–19 km), showing a vertically expansive cumulate system down to the intruded lower crust (or Moho). Strong spatial trends indicate that structure influenced magma extraction, highlighting the complex interplay of tectonics, mantle flux, and crustal heat flow in the central TVZ

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Acoustic and geomorphic predictors of hydrothermal vents in an active back arc, offshore Taupō Volcanic Zone, New Zealand

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3A: Unravelling the Seascape, C1, November 23, 2020, 4:00 PM - 5:30 PM

Seafloor seeps and vents are often correlated with anomalous patches of high backscatter reflectivity, often interpreted to be hardgrounds diagnostic of past or present fluid expulsion. Multibeam echosounder (MBES) frequency choice influences backscatter reflectivity measured and thus our ability to accurately link hard grounds with fluid expulsion. We present a classification approach of hydrothermal seeps in the Calypso Hydrothermal Vent Field (HVF) in the offshore Taupō Volcanic Zone, New Zealand using image segmentation and random forest modelling. Our methodology aims to (a) quantify the discriminatory power of two different backscatter frequencies on mapping hardground and hydrothermal activity extent, (b) determine the predictive accuracy after modelling known fluid expulsion (water column acoustic flares) to speculated hardgrounds (high amplitude seafloor backscatter patterns), and (c) determine if combining two backscatter frequencies increases or degrades model accuracy. We link backscatter and bathymetric variables generated from two synchronous multibeam echo sounders, a Kongsberg EM302 30 kHz and an EM2040 120 kHz MBES, to more than 3000 shallow (150 – 200 m water depth) hydrothermal seeps in the Calypso Hydrothermal Vent Field (HVF) in the offshore Taupō Volcanic Zone, New Zealand to determine if a paired-frequency approach, within the capability of conventional multibeam systems, will lead to improved seafloor prediction models and improve our understanding of seep genesis through their lifecycle stages.

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Communicating the Geology of the Otago Central Rail Trail

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8A: Geo-Teaching & Practice, C1, November 25, 2020, 11:00 AM - 1:00 PM

The Otago Central Rail Trail (OCRT) is a 152km long recreational trail that follows the former Otago Central Railway line between Middlemarch and Clyde. In doing so it passes through a variety of rock types, from the famous Otago Schist, through variously fossil-laden and gold-bearing sediments, to the remnants of extinct volcanoes. The unique geological landscape of the trail records the history of southern New Zealand from the time of Gondwana through to the uplift of a geologically recent basin and range province that has played a key role in the natural and cultural development of the region. And yet, most of the 80,000 people who annually utilise the trail are virtually unaware of this fascinating past.

In conjunction with the OCRT Trust and the University of Otago's Centre for Science Communication a project was undertaken to develop easily accessible and engaging geoscientific resources for the OCRT Trust to use in future upgrades to the trail signage, website, or other interpretive materials. The project consisted of a desktop survey supplemented by geological mapping of outcrops along the trail to produce not only a general overview of the geological evolution of Central Otago and specific regions therein, but also an exploration of the relationships between the rocks, animals, plants and people that have and continue to inhabit this unique part of the world. Similarly Points of Interest were identified along the trail where visitors can stop, see and touch various geological phenomenon.

It is hoped that the outcomes of this project will enhance visitor enjoyment, appreciation and engagement with the trail and surrounding region, and provide materials applicable to NCEA unit standards relating to Earth Science.

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The Birth of an Intraplate Volcano: Characterising the Onset of Volcanism at the Dunedin Volcano, New Zealand

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The Dunedin Volcano is a composite shield volcano situated within the South Island of New Zealand. It formed as the single largest centre of the Dunedin Volcanic Group, lying within the monogenetic Waipiata Volcanic Field. With activity spanning 5 million years (16.0 ± 0.4 to 11.0 ± 0.2 Ma), encompassing submarine through to subaerial volcanism, this alkaline intraplate volcano (which comprised numerous vents that produced a vast array of compositionally diverse pyroclastic and flow deposits) holds the record of a complex eruptive history.

Products of successive eruptions buried the earliest volcanic deposits, making it a challenge to characterise and fully understand the onset of activity. The Dunedin Volcano, however, hosts localised areas where pre-volcanic sedimentary inliers are exposed. At these locations, the relationships of pre-eruption rocks with the overlying volcanics offer a unique window through which we gain insight into the initiation of volcanism. Each inlier offers potential snapshots of events during the early life of the volcano.

Here we present an extensive review of previously published work regarding these sedimentary inliers. Evidence indicates that initial activity was submarine and contemporaneous with sedimentation, as shown by the presence of basaltic and trachytic tuffs interbedded within the Miocene sedimentary sequence.

We will expand upon this and analyse crystal size- and grain size distributions particle morphology and pyroclast vesicularity to assess the origins of different early pyroclastic deposits and to separate them from products of sedimentary reworking. In so doing, we aim to determine the processes and eruptive patterns when the Dunedin Volcano was becoming established. Did it form by activity fundamentally different from volcanism in the broader Waipiata Volcanic Field? Or did it develop through little more than an intensification and localisation of the same style of activity as elsewhere in the field?

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Kuwae: a South Pacific source of a global climate changing eruption?

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

According to ice core and tree growth records, the three eruptions with the greatest atmospheric impact over the last 1000 years occurred around AD 1257, 1453 and 1815. The 1815 eruption took place in historical times at Tambora, and the 1258 event was recently attributed to Samalas volcano, Indonesia. The source of the mid 15th-century eruption, however, remains a matter of mystery. While its location is uncertain, it was large enough to produce acid peaks in both Antarctic and Greenland ice cores. This implies that the eruptive column reached the stratosphere before spreading globally. The 30 years following this eruption are often cited as among the coldest within the last 1000 years, at least partly attributed to the eruption.

Since the mid 1990s, Kuwae caldera, Vanuatu, is among the top candidates as the source for the 15th century eruption, evidenced by cultural, archaeological and geological studies. However there remain large uncertainties concerning the exact timing and the volume, composition, magnitude and dynamics of the eruption. Today, the mainly shallow submarine Kuwae caldera lies between the islands of Epi and Tongoa, with the latest known eruptions in 1974.

We will assess whether Kuwae is the source of a global clmate-forcing eruption. Its location at 16° 15' South, modest estimated size (<40 km^3), submarine setting and andesitic composition make it an unlikely candidate. On the other hand, a high-energy intermediate-composition Plinian eruption may produce efficient sulphur loading in the upper atmosphere. We will combine bathymetry studies, volcano-sedimentological and geochemical studies, and wiggle-match radiocarbon dating to characterise the deposits surrounding the Kuwae caldera. Through this we will also define the volatile budgets and regional hazard potential at a mafic caldera volcano, typical of several others known in the Southwest Pacific.

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Two-staged uplift of the Transantarctic Mountains with constraints from the Cretaceous geology of southern New Zealand

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Many continental rift margins of the world show a two staged uplift and exhumation process separated by an ~ 50 myr gap (Japsen et al, 2012). One of the well documented cases is the Transantarctic mountains where fission track data show an initial mid Cretaceous phase followed by a stronger phase of uplift at 55 Ma (Fitzgerald, 2002).
Southern New Zealand was contiguous with the Ross Embayment in the pre-break up of Gondwana. Recent geological studies (Lamb et al and Lamb and Mortimer,2020) from the Alpine Fault of southern New Zealand provide a timing framework for extension and strike-slip faulting in the Ross Embayment. About 270 km of sinistral motion is inferred to have occurred on the Alpine fault in the Cretaceous and this would be the predicted amount of Cretaceous extension in the Ross Embayment.

We propose a generalised process whereby the initial phase of uplift is caused by rifting and strike-slip faulting. Mechanical uplift is generated by isostatic forces generated through normal faulting, and the transtensional nature of the faulting extends into the mantle lithosphere to create an unstable edge or step. There is a long period of slow growth of the instability before its growth becomes exponential, and it activates as a migrating instability. For reasonable mantle viscosities and lithospheric thicknesses that the "spin-up tail" is of the order of several 10s of millions of years and hence consistent with the ~ 50 myr gap seen between the two uplift phases. Growth of such an instability will drive uplift at the TAM front as old dense mantle lithosphere is removed, and replaced by buoyant upper mantle.

Clyde Dam, Otago: 40 years of hazards science

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7B: Active Tectonics, C2, November 25, 2020, 8:30 AM - 10:30 AM

The Clyde Dam is the largest concrete gravity dam in New Zealand. The dam was constructed in the 1980s, with considerable investigatory work carried out prior to, during, and post dam construction. The early 1980s saw New Zealand's first significant paleoseismic studies, which were carried out on the local Dunstan Fault. Dam site foundation excavations also resulted in the discovery of the River Channel Fault, requiring development of a slip-joint in the dam design to accommodate the possibility of triggered slip in the event of a Dunstan Fault earthquake. The late 1980s then saw major investigations into the stability of landslides on the flanks of the Cromwell Gorge, and substantial remediation measures put in place. The last 15 years have seen a major, multi-phase re-evaluation of the seismic hazard for the dam site. Significant aspects of the seismic hazard assessment comprise: relocation of the Dunstan Fault to a position downstream of the dam, placing the dam in a hanging wall setting; new paleoseismic investigations that show strongly aperiodic earthquake behaviour on the fault; a probabilistic seismic hazard analysis as comprehensive as those carried out for nuclear power plants; and the first-ever use of ancient fragile geologic features to constrain the final design earthquake motions. The final motions are similar to the original design motions from the 1980s, but only coincidentally so.

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What is Project EAST?

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

In recent decades, research and monitoring programs across the world have reported widespread coastal and marine environment degradation. The cumulative impacts of human occupation, land-use runoff, aquaculture, marine vessels, and unsustainable fishing practises are thought to have contributed to localised collapse of marine ecosystems and damage to the seafloor.

In New Zealand, only a small fraction (<30%) of the Exclusive Economic Zone waters are protected. There is an urgent need to increase our understanding of unprotected coastal and environments and how they are affected by human activities. The health of the coastal and shallow marine zone has been identified as a key research priority in New Zealand, due to its cultural, social, ecological, and economic importance.

Project EAST is a multidisciplinary project with an holistic approach that aims to integrate the understanding of Ecosystems, Anthropogenic impact, Sediment dynamics, and Taiao.

Here we present our first case study from Queen Charlotte Sound-Tōtaranui, Marlborough Sounds. We use high-quality bathymetry data to evaluate the impact of human activities on seafloor morphology (i.e. dredging, mooring blocks, anchor marks) and benthic habitats distribution. Water and sediment samples are used together with water column data to evaluate the hydrographic structure and distribution of suspended sediment. This case study will address target areas that are potentially at risk due to human activities.

The outcomes of this case study demonstrate the type of information that can be used for marine management measures that will be an essential response to growing pressures on coastal and marine environment in New Zealand.

Spatio-temporal flow processes of a co-seismic turbidite: the Kaikōura Turbidite

Dr Lorna Strachan[1], Dr Alan Orpin[2], Dr Jamie Howarth[3], Dr Helen Bostock[4], Dr Philip Barnes[2], Ms Stephanie Tickle[3], Mr Joshua Malone[5], Dr Katherine Maier[2], Dr Joshu Mountjoy[2], Dr Scott Nodder[2], Ms Abigail Willis[6]

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2A: Unravelling the Seascape, C1, November 23, 2020, 1:30 PM - 3:30 PM

The Mw 7.8 2016 Kaikōura earthquake triggered multiple submarine slope failures along a >200 km length of the Hikurangi subduction margin. Once initiated, within-canyon acceleration and flow-ignition resulted in turbidity current generation from ten adjacent distributary systems, where debouching flows converged and amalgamated within the Hikurangi Channel. Our previous work using post-earthquake sea-floor mapping and sediment cores has demonstrated that the co-seismic turbidity current travelled >680 km along the Hikurangi Channel, depositing an event bed ranging in thickness from 20–650 mm.

Here we present a detailed overview of deposit characteristics of the co-seismic Kaikōura turbidite focussing on spatial variability within: 1) distributary canyons; 2) along the Hikurangi Channel thalweg, and 3) transects across the Hikurangi Channel-levee. Turbidites are composed of sand and mud (clay-silt), and display a variety of vertical grading patterns ranging from normal grading to complex vertical grading patterns where stacked non-graded to normal graded intervals are observed and overlain by a muddy cap. A range of primary sedimentary structures are observed including non-cohesive tractional bedforms (ripples, climbing ripples, and upper stage plane beds), and transitional flow bedforms (between turbulent and laminar) including oversteepened ripples, washed out ripples, and low-amplitude bedwaves. Soft-sediment deformation structures including load and flame structures, convolute laminae, and dewatering pipes/sheets are common, as are muddy debrites in the most down-flow deposits.

We will present a spatio-temporal model showing flow evolution. A variety of flow behaviours are inferred that vary as a function of deposit distance from source and temporal evolution. Counter to conventional deposit models for landslide triggered turbidity currents, such as the famous Bouma sequence, we observe a spatially varied bed that thickens down flow. Downcurrent deposit variability suggests that the flow became more cohesive with time, with turbulence modulation resulting in the deposition of transitional bedforms including quasi-plug flows (linked debrites).

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Covid-19 induced online sedimentology teaching: an opportunity for the integration of digital Earthscience technologies into 21st century curricula

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9A: Geo-Teaching & Practice, C1, November 25, 2020, 2:30 PM - 3:30 PM

Within the last decade, practising Earthscientists have seen a rapid shift to the routine use of digital technologies including geospatial techniques (GIS), outcrop capture (LiDAR data), photogrammetry, satellite imagery, and 4D reservoir modelling. Yet many teaching courses have not kept pace with technology, due to limitations of resources, cost, and time. Through Covid-19 induced necessity, many were forced to pivot to online delivery, and rushed development of online resources and virtual field trips. For some this was a stop-gap, until "normal" teaching modes resume, while for others this was an opportunity to develop new resources and online delivery modes.

Here, we use the case study example of a 3rd year Sedimentology class (Sedimentary Systems) to highlight the approach taken to pivot towards a new mode of delivery. We built a connected curriculum with integrated lecture, lab, and field components, that allowed students to incrementally expand and deepen their knowledge. Effort was focussed on developing the online practical part of the course (labs and fieldtrip), with the strategic decision to develop a future hybrid teaching model with a mixture of face to face and online labs. We designed and built 8 blended online labs hosted in a purpose-built website. Each lab was designed to be student-led, and allowed them to work through a series of problems providing training for a virtual field trip. We developed a new 1-day virtual field trip to One Tree point, Whangarei. Two weeks prior to national lockdown, we collected field data (sediment samples and paleocurrents), and recorded 360˚ videos and photo material. These were integrated with a youtube channel, and pre-existing data to provide a student-led online virtual fieldtrip. We plan to build a drone model for the outcrop to create an immersive field experience which we hope to couple with a physical trip in 2021.

Crustal structure and subduction geometry in southern South Island, New Zealand.

<u>Dr Wanda Stratford</u>[1], **Dr Calum Chamberlain[2], Professor Rupert Sutherland[2], Professor Timothy Stern[2]**
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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The Southland Seismic project used an offshore seismic source from a multichannel survey in Solander Basin to recorded seismic energy onshore on seismographs in Southland and Fiordland. Seismographs (37) were deployed in two arrays in line with the offshore shots, enabling the construction of two onshore-offshore crustal structure models for the region. The project piggy-backed off a 2018-19, NZ-USA, international project across the Puysegur subduction zone. The Fiordland and Southland regions are still relatively poorly explored but are affected by New Zealand's most seismically active subduction zone the Fiordland-Puysegur subduction system. Little is known about the structure, shape, depth-extent and seismic hazard potential of the subduction system for southern South Island or how it is deforming the overriding plate. From a global viewpoint, this margin is important as it is regarded as a rare example of a young, and evolving, subduction system. Because of poor earthquake locations in this isolated region, there are still counter views on the shape of the plate at the point of downward inflection just off the south coast. Here is where the subduction zone changes from a relatively normal looking subduction geometry offshore and over a short distance undergoes ~17-degree bend in strike and is contorted to a ~vertical dip.

We present onshore-offshore seismic data and preliminary models from the bend region that improve our understanding of the structure and physical properties of the lithosphere for southern South Island, New Zealand.

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Micro-gravity Survey of the Wellington CBD for Basin Structure and 3D Ground Motion Simulations

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Sedimentary basins enhance amplification of earthquake shaking, and New Zealand Standard (NZS) 1170.5 relies on depth to bedrock as a proxy for expected amplification, giving corresponding minimum structural requirements for new buildings. Damage in the Wellington suburbs of Thorndon and Pipitea during the 2013 Cook Strait and 2016 Kaikōura earthquakes suggest that in places the depth to bedrock in Wellington City is being underestimated, and/or that 3D basin effects, such as constructive interference at edges, generation of surface waves and focusing, caused enhanced shaking. These effects are significant enough they need to be isolated then accounted for in the building code. More detailed knowledge of basin geometry is therefore required, which is currently hindered by a lack of deep boreholes.

A micro-gravity survey across the Wellington CBD (funded by EQC) is being undertaken to address these issues, using Victoria University of Wellington's high precision Scintrex CG-6 gravity meter. The project will collect up to 500 new microgravity measurements across the city. Both 2D and 3D inverse modelling is being undertaken using the geophysical software package Oasis Montaj. Preliminary results indicate that the recently discovered Aotea Fault (Barnes et al., 2018), bounding the eastern edge of the Wellington basin, lies close to its currently interpreted position and dips steeply west. The adjacent Pleistocene sediment is ~140 m thick, agreeing well with existing models (Kaiser et al., 2019), but this study suggests thicker sediment than expected westward into the basin. Active source seismic deployments are also being undertaken, and shear wave reflections are evident in collected records which could provide an independent control on basin depth. Data collection from now will focus on the Thorndon area, which contains most of the reclaimed land around the foreshore and has the greatest expected sediment depths.

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Thinning history of Byrd and Mulock Glaciers: A preliminary field report

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Response of the West Antarctic Ice Sheet (WAIS) to projected warming remains a significant uncertainty in sea level rise projections. The aim of this project is to provide understanding of past mechanisms and feedbacks of ice sheet retreat, to reduce uncertainty in projections of future change. We will extend the observational record of ice sheets by targeting strategic locations around the margins of the Ross Ice Shelf, where glacial sediments deposited on nunataks next to dynamic ice margins record the transient evolution of the ice surface elevation immediately prior to the observation period. Our cosmogenic surface exposure chronologies from these sites will quantitatively constrain (i) past rates of ice thinning; (ii) total magnitudes of ice elevation change; and (iii) the absolute timing of ice discharge and thinning events in these sensitive regions. Our new ice thinning histories will inform high-resolution, sector-scale numerical glacier model experiments, in which we will seek to determine drivers of ice discharge events.

Field work undertaken during the 2019-20 field season focused on outcrops along the Byrd and Mulock glacier catchments. Overall, ~30 samples of bedrock and glacial erratics were collected for cosmogenic surface exposure dating. Main highlights include i) rich assortment of erratic cobbles found at Lonewolf Nunataks indicate that upper surface of the Byrd Glacier has previously been at least 250 m thicker than present and ii) Striated bedrock surfaces and glacial erratics found mid-way up Mt. Marvel indicate that Mulock Glacier was previously thicker, and that local flow paths were different to present.

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A blast from the past: Lithological influences on hydrothermal eruption potential, New Zealand.

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Hydrothermal eruptions are violent explosive events driven by expansion of superheated water and steam from a suddenly ruptured, pressurised aquifer. They eject water, steam, and rock as ballistics, or in debris jets and wet surges. They are not confined to volcano-hydrothermal systems (e.g., Whakaari), but are common to many geothermal fields. In the Central North Island, very large hydrothermal eruptions are known from: Waiotapu, Waimungu, Okaro, Whakarewarewa, Rainbow Mountain, Rotokawa, Te Kopia and elsewhere – away from direct magma contact, but strongly influenced by rifting tectonics. These geothermal fields are iconic tourist attractions and critical resources for low-carbon renewable energy generation. Understanding the explosive and hazard potential of hydrothermal events has lagged volcanic studies. Here we examined the properties of typical Central North Island lithologies via explosive decompression experiments.

Across multiple geothermal areas within the Taupo Volcanic Zone, hydrothermal eruption breccias include typically four main lithotypes: (1) glassy, pumice-rich tuff derived from variably welded ignimbrites; (2) mineral sandstone or microbreccia comprising mainly quartz and feldspar crystals cemented by silica or calcite; (3) polymictic breccias - clasts of hydrothermal breccias from earlier eruptions, and typically strongly cemented by silica; and (4) fine-grained, low-energy fluvial mudstones. These are all variably overprinted by argillic to prophylitic alteration.

The lowest density and permeability clasts (2 and 3) are generally the strongest, but also show decompression-fragmentation thresholds above the theoretical strength (based on porosity). Even the highest porosity/permeability and weakest clasts, especially (1), show stronger than theoretical properties, mainly due to alteration, especially silicification. Calcite-cemented lithologies are much weaker than expected from their porosity. Variable proportions of these different lithotypes in an eruption source zone will strongly influence hydrothermal eruption hazard properties of: eruption size, crater dimension and ballistic ejection velocity.

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Constrained geopotential modelling of the ocean cavity and geology beneath the Ross Ice Shelf

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The ice flux across the grounding zone of the Ross Ice Shelf is influenced by (1) the basal conditions of the ice sheet and (2) buttressing of the ice shelf. These two factors are strongly tied to the local geology. Geothermal heat flow influences ice sheet flow rates through meltwater production and increased englacial temperatures. Sub- ice shelf bathymetry guides ocean water circulations, responsible for melting and freezing of the base of the ice shelf. This melting and freezing changes the geometry of the shelf, which may impact its buttressing of the upstream ice. To better model the contribution of the Ross Ice Shelf to future sea level rise, the geothermal heat flow and the bathymetry of this region must be constrained. Here I present three general objectives for my research in the coming years of my PhD: (1) use magnetics data to estimate geothermal heat flow across the Ross Ice Shelf region, (2) perform a gravity inversion to improve the resolution of bathymetry under the shelf, and (3) create a crustal scale geologic model of the region. Results from these objectives, including the depth to basement and the locations of faults, intrusions, and volcanism, will provide information on the tectonic, geologic, and glaciologic histories of the Ross Embayment, an area with a diverse and enigmatic history.

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The Conditions and Dynamics of Magma Fragmentation and Plume Stability during the Y5 Phase of the Taupo 232 CE Eruption

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5A: Volcanism, C1, November 24, 2020, 11:00 AM - 1:00 PM

Unit 5 (Y5) of the Taupo 232 CE eruption is an unusually well-preserved and well-studied example of a large Plinian fall deposit. Existing studies, however, lack an in-depth quantitative investigation into the fragmentation and sedimentation dynamics of this eruption, particularly in association with the sustained eruptive cloud and its coeval, periodic phases of collapse (known as the Early Flow Units or EFU). Here we compare the vertical time variations between the air-fall and pyroclastic density current (PDC) phases of the Y5 eruption via grain-size analysis and the quantification of eruptive components, their densities, and the textural characteristics of juvenile clasts through in-depth analysis of three distinct locations: A) an extremely well-detailed air-fall profile; B) an EFU sample from a PDC dominant location, and; C) a profile comprised of air-fall deposits interbedded with dilute PDCs. Four major juvenile component classes are defined: 1) microvesicular pumice; 2) macrovesicular pumice; 3) dense grey, and; 4) obsidian; which exhibit a systematic increase in bulk densities, respectively. The macrovesicular pumices also display a wide range of microtextural features, with minimal to extreme amounts of shearing and variation in porous connectivity. Non-juvenile component classes were divided according to broad estimates of their likely depth of origin (shallow lavas, intermediate lacustrine sediments and deep plutonic country rock) to infer the behaviour of vent excavation during the eruption. The quantitative results allow for the reconstruction of the likely conditions in the conduit immediately prior to fragmentation and how this varied with time, adding further complexity to the understanding of the Y5 eruption.

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Temporal change in the rupture velocity of repeating earthquakes occurring in and around the source area of the 2011 Tohoku-oki earthquake, NE Japan

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The numerical simulation of fault slip by Chen et al. (2010) showed that the relationship between the recurrence interval Tr and seismic moment Mo of repeating earthquakes (repeaters) varies depending on the ratio of the velocity-weakening patch size r to the critical nucleation size h*. Tateiwa et al. (2020) investigated the relationship between Tr and Mo of small repeaters occurring in and around the source area of the Tohoku-oki earthquake in northeastern Japan and estimated that r/h* is small in an area (Region 1) using the result of Chen et al. (2010). The analysis of the corner frequency fc of repeaters occurring in this region suggested that the increase in loading rate due to the afterslip of the 2011 Tohoku-oki earthquake may have led to a decrease in h* and an increase in the rupture velocity Vr after the Tohoku-oki earthquake. In this study, we estimated Vr of these repeaters to confirm whether the temporal change of Vr actually occurred.

We estimated Vr from the azimuthal variation of fc obtained by array of onshore (Hi-net) stations. Vr was found to be large immediately after the Tohoku-oki earthquake and decrease with time in Region 1. This is consistent with the assumption that the afterslip decayed and h* increased after the Tohoku-oki earthquake. The temporal change of Vr is consistent with the expectation from the magnitude of r/h* inferred from the Tr-Mo relationship and temporal change in loading rate due to the afterslip, that is, Vr is considered to be negatively and positively related to h* and the loading rate, respectively. This supports the idea of our previous study which suggests that the Tr-Mo relationship reflects the variation of r/h*, or the frictional properties.

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GeoNet Sensor Network Capability; Estimates of the Earthquake Detectability in New Zealand

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The GeoNet monitoring project is nearing its 20th birthday. The associated sensor network has reached a high level of maturity with a dense New Zealand based near real-time seismic sensor network covering the entire country. The GeoNet seismic sensor network was primarily designed for national and regional earthquake detection and volcano monitoring, originating as a patchwork of regional research networks and a sparse national network. Network development since its inception has filled in many gaps and densified the network where monitoring or research needs required it, resulting in the seismic sensor network we see today.

Here we present a simple approach for assessing seismic sensor network capability using estimates of minimum detectable earthquake magnitude based upon network geometry and an average noise measurement for each site in the network. To do this we implemented the SN-CAST algorithm (Möllhoff et al., 2019) using a modified local magnitude scale for New Zealand (Ristau et al., 2016). We find that the estimates of minimum detectable earthquake magnitude produced by the SN-CAST algorithm are to a first approximation in line with data extracted from the GeoNet earthquake catalog and the operational expectations of the GeoNet seismic sensor network.

Long term, this work may inform near real-time analysis of the seismic network's capability, however static assessments like this can be readily applied to network design and targeted capability improvements through their tunability and independence from earthquake catalogues.

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Lessons from Early career Māori researchers working with Māori communities on community-based risk and resilience research

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3B: Hazards Symposium, C2, November 23, 2020, 4:00 PM – 5:30 PM

Despite increasing attention on the importance of earthquake and tsunami risk reduction for Aotearoa New Zealand communities, there are limited Māori-medium resources available, and more representation of Māori, and wāhine (women) researchers is needed within the field. Kristie-Lee Thomas and Lucy Kaiser will talk to key learnings from theirs, and their colleague Emily Campbell's experience utilising a range of novel approaches to engagement and collaboration including traditional story-telling, Mātauranga Māori (Māori knowledge) and design technologies to increase resilience for Māori communities from tamariki (children) to kaumatua (elders) during recent community-based research projects. Weaving together these projects is a wider narrative of ethnographic reflection exploring the role of three emerging wāhine researchers collaborating in the discipline of DRR research and the challenges and successes involved within this. A number of themes emerge from their collective experiences including the importance of maintaining a Te Ao Māori or bicultural lens, engagement, reciprocity and academic and cultural support. From our experiences as early career Māori researchers and in light of the suggestions in the work of our Māori and indigenous colleagues we offer a number of initiatives for universities, research institutions and researchers to consider, for supporting a pathway to a strengthened, inclusive and diverse earthquake/tsunami resilience field.

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Water chemistry and ice mechanics

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Experimentally derived flow laws, such as the Glen flow law, describe the strength of polycrystalline ice for given stresses and temperatures and are crucial in modelling the flow and response of ice sheets, such as the West Antarctic Ice Sheet, in a warming climate. All existing flow laws are based on experiments that use pure water ice, free of soluble (chemical) and insoluble (particulate) impurities. Natural Antarctic ice is not pure water ice. Past work has shown impure ice tends to be weaker than pure water ice, as intracrystalline impurities should encourage the formation of crystal defects and deformation of grains. As ice flows, the impurities are swept to grain boundaries and influence mechanical behaviour by inhibiting grain growth and recrystallisation. This is seen in natural ice cores, with higher concentrations of ionic species found in finer grained bands of ice. Chemical effects have proven difficult to quantify, as distinct chemical species appear to behave differently; Recent work has shown Ca2+ ions have a hardening effect, while H2SO4 enhances creep rates in ice. In this study, ice with major ion chemical compositions comparable to coastal and central Antarctic ice has been synthesised, and deformed in a series of uniaxial compression experiments at varying strain rates (10-4, 10-5, 5x10-6 s-1) and temperatures (-10 and -30°C) at the University of Pennsylvania. Mechanical data suggest chemistry has no significant effect on the strength of ice at colder temperatures, while at warmer temperatures and slower strain rates impurity content has a strengthening effect. This has interesting implications for ice sheet flow; The majority of deformation is constrained to the base and margins of slow flowing (10-13 – 10-10 s-1) ice sheets and glaciers, where englacial temperature is highest. This suggests insoluble impurities or higher ionic concentrations may contribute to the softening of natural ice.

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Assessing the merits of different educational outreach activities

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8A: Geo-Teaching & Practice, C1, November 25, 2020, 11:00 AM - 1:00 PM

Across different geoscience research organisations and programmes in Aotearoa New Zealand, a wide variety of educational outreach activities are undertaken to communicate and engage with the public. These range from ‘live’ (person to person) presentations, field trips and workshops, to online offerings such as school lesson plans, websites or YouTube videos. It is possible to organise such activities in a spontaneous ad hoc manner, or to think more holistically about how they fit in to a longer term outreach strategy. Some consideration about their relative merits helps answer the question about where to focus the available energy and resources over time for best effect.

So is it possible to usefully compare the costs vs potential benefits of diverse outreach activities?

In this presentation, Julian Thomson will draw on his years as a teacher and science outreach educator to offer some thoughts about how to approach this question.
The presentation could be of value to anyone wanting to develop or revue an educational outreach strategy for their department or research programme.

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Distinguishing turbidite tails from background sedimentation on the Hikurangi Margin and its implications for dating turbidites

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7B: Active Tectonics, C2, November 25, 2020, 8:30 AM - 10:30 AM

The Hikurangi margin is one of the largest sources of seismic and tsunami hazard in New Zealand, but little is known about previous ruptures on the subduction interface. Turbidite paleoseismology has the potential to increase the spatial density and temporal extent of paleoearthquake records. However, it is heavily reliant on temporal correlation of turbidites, and thus, requires them to be precisely dated. Typically, ages are obtained using radiocarbon dating of pelagic foraminifera from background sediments deposited between turbidites. This dating method requires background sedimentation to be accurately distinguished from the fine-grained tails of turbidites. Along the southern and central Hikurangi Margin, background sedimentation and turbidite tails have proven difficult to distinguish from one another. Here, we develop an approach to quantitatively distinguish turbidite tails and background sediments using machine learning. We utilize a natural experiment generated by the M_W 7.8 Kaikōura earthquake, which caused the deposition of co-seismic turbidites at locations both proximal and distal to active canyon systems. Turbidites and background sedimentation were identified independently using the stratigraphic position of the 2016 turbidite at core tops and ^{210}Pb activity profiles combined with foraminiferal assemblages to confirm the presence of background sediments overlain by turbidites. The physical and geochemical properties of the sediments were then analysed using non-destructive (CT density, magnetic susceptibility, micro-XRF derived geochemistry) and destructive (grain size, carbonate content, organic content) techniques, to develop a quantitative definition of turbidite tails and background sediments. The machine learning technique, Linear Discriminant Analysis (LDA) was used to model the differences between these two groups. The LDA successfully distinguishes background sediment and turbidite tails in areas where they are visually indistinguishable. This study shows that quantitative identification of background sediments and turbidite tails is possible, and could allow for more robust identification and dating of turbidites globally.

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Glacial geomorphology of the Ahuriri River valley, central Southern Alps, New Zealand

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Some valleys in South Island, New Zealand already have a number of well-dated glacier records. However, understanding of the precise timing of old glacial events in many valleys still remains poor. For this purpose, the cosmogenic 10Be surface exposure dating technique was used to constrain the timing and extent of late Quaternary glaciation in the Ahuriri River valley, Southern Alps, New Zealand. The 32 10Be surface-exposure ages from two different moraine complexes range from 16.6±0.4 ka to 19.7±0.5 ka suggesting rapid glacier recession (~17 km) during the last deglaciation.

Field observation and geomorphological mapping were also used to investigate the extent and drivers of glaciation in this valley. For the final step, we created unprecedented detail and comprehensive map of the glacial geomorphology in an area covered by palaeo Ahuriri Glacier, in the central Southern Alps. Geomorphological mapping from high-resolution aerial imagery, large scale topographical maps, average resolution DEM, and several field investigation allowed us to produce this 1:38,000 scale map for the entire study site covering an area of about 532 km2.

This newly created map along with the new 10Be surface exposure dataset will help us in better understanding of past glacier-climate interactions in the Southern Alps and in the Southern Hemisphere in general.

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Petrology and geochemistry of a suite of intrusive igneous rocks from the Kermadec Arc-Havre Trough, SW Pacific

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Magmatism at oceanic subduction zones can provide insights into processes that occur during subduction such as the transfer of material between the surface and depth, as well as magma generation and the evolution arc crust over time. Studies of these processes are usually undertaken using volcanic (eruptive) samples as these are the easiest and most abundant to sample, especially in an oceanic arc environment.

A rare suite of intrusive igneous rocks has been dredged from a basin in the easternmost Havre Trough; Basin E, a ~3 km deep basin, located immediately north of Rumble II West volcano, Kermadec Arc during the R.V. Tangaroa voyage TAN1213. Textural and geochemical analysis of these rocks can provide insights into magmatic processes and crustal evolution within the deeper oceanic arc and complement the volcanic samples previously studied from this archetypical oceanic subduction system.

The sample suite comprises 10 individual blocks ranging in size from 0.25 to 4.5 kg. They are crystalline granular and have broadly phaneritic textures with grain sizes ≤1mm. The samples are variably altered due to the time exposed on the seafloor. Four representative samples were selected for mineralogical analysis. The mineral assemblage is Plagioclase + Clinopyroxene ± Amphibole ± Orthoclase ± Quartz with rare magnetite, ilmenite, apatite, and chalcopyrite. Plagioclase compositions indicate that the samples have a close affinity with those erupted from Rumble II West volcano and Rapuhia seamount. Thus, the samples are interpreted to represent magmatism associated with the modern Kermadec Arc-Havre Trough, rather than the older attenuated crust of the Miocene Colville Arc.

Further mineralogical analysis of the suite will be used to investigate the tectono-magmatic processes of the Kermadec Arc-Havre Trough and the processes that can occur at depth within the magmatic plumbing system and how this links to previously studied volcanic samples from the region.

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High resolution gravity constraints on variations of properties across the East-West Antarctic mantle transition

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The transition zone between East and West Antarctica is unusual for a stable intracontinental region in that it displays strong geophysical signals which suggest active tectonics. These include a high gradient in upper mantle shear-wave velocity, a steep gradient in gravity anomalies, and Cenozoic uplift of one of the longest and highest mountain ranges in the word. At present the characteristics within this zone such as viscosity and density of the lithospheric mantle are poorly understood. My research aims to improve constraints on these properties by modelling gravity data collected in the Taylor Valley of Antarctica. The strength of gravity is strongly controlled by variations in mass within the subsurface and when paired with seismic data can be used as a proxy to determine both densities and viscosities of the mantle. Our models incorporate gravity data previously collected in the Dry Valleys and improves on existing models due to the recent availability of new high-resolution digital elevation models (DEMs) and modern GPS and gravimetry equipment.

Better constraints on the lithospheric mantle variation across East and West Antarctica will reduce uncertainty in future post-glacial rebound (PGR) models of the Ross Embayment – TAM sector of Antarctica. The implications of these improved models, which predict changes in surface elevation to ice retreat, are in better monitoring of Antarctica ice mass loss and melt contribution to changes in present day global sea level. Further, by increasing constraints on properties of viscosity below the Transantarctic mountains, understanding of the deglaciation history across this region over the last 20,000 years will be improved. This knowledge is not only interesting from a geological standpoint, but also vital in resolving the input Antarctica ice sheets have on present day sea level in the context of the warming climate.

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Integrating proxy and model estimates of Antarctic climate variability over the last millennium

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2C: Cryosphere, C3, November 23, 2020, 1:30 PM - 3:30 PM

Our understanding of how changes in global mean climate state will affect the Antarctic Ice Sheets is limited by the short duration of the instrumental period. Observational records routinely used to develop and evaluate predictive models are not long enough to characterize a climatological baseline in the highly variable southern high latitudes. Here, we investigate the long-term drivers of Antarctic climate and sea ice dynamics by comparing paleoenvironmental reconstructions and simulations of late Holocene conditions (850 – 2005 CE) from the Community Earth System Model Last Millennium Ensemble (CESM-LME).

Last millennium cooling observed in proxy records from the Antarctic has a robust physical basis: in LME simulations global temperature decline between 850 CE and 1850 CE due to changes volcanic, solar, and orbital forcing. The contrast between a warmer "Medieval Climate Anomaly" (850 - 1250 CE) and cooler "Little Ice Age" (1450 - 1850) is most pronounced at the poles with an average of 0.55˚ C of cooling in the Arctic and 0.2˚ of cooling in the Antarctic in full forcing simulations. Greater cooling at the northern high latitudes is the result of differing ice-ocean feedbacks in the Arctic and Southern Oceans following major volcanic eruptions.

However, the LME does not resolve the spatial pattern of warming and cooling observed in Antarctic proxy records. The LME simulates a continent-wide cooling trend over the last millennium while ice core reconstructions indicate that parts of Western Antarctica and the Eastern Ross Sea warmed since 1000 CE. We propose that both proxy uncertainties and model bias associated with the representation of the Southern Annular Mode likely contribute to the observed proxy-model mismatch.

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Teaching science communication in the time of crisis: Updating the Auckland Volcanic Field simulation

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9A: Geo-Teaching & Practice, C1, November 25, 2020, 2:30 PM - 3:30 PM

Simulation exercises are used regularly to train emergency management personnel for crises. For over a decade, Frontiers Abroad, University of Canterbury, and University of Auckland (UoA) have used a volcanic eruption simulation exercise to teach lessons about eruptions, emergency management, and science communication to university students. Over the past four years, the University of Auckland has modified the Auckland Volcanic Field (AVF) volcanic eruption simulation; here, we unveil the newest version of the AVF simulation. Several updates are introduced. First, the scenario has been changed from the exercise Rūaumoko eruption sequence to the Birkenhead Scenario developed by the multi-disciplinary DEtermining VOlcanic Risk in Auckland (DEVORA) programme and can easily be interchanged with scenarios DEVORA suite. Second, new software solutions have been developed to provide additional functionality and student access to geographical information system (GIS) datasets. Third, new student roles, including social media coordinators and GIS specialists, have been introduced to reflect changing technology. Some pre-existing student roles were also renamed to align more closely with titles in the coordinated incident management system. Fourth, introducing new roles necessitated updating the challenge questions (work prompts) given to the students during the exercise. Fifth, assigned readings were updated to include recent literature. Finally, extra science communication tasks were added to ensure every student had the opportunity to interact with "the media," a group of students from UoA's Media and Communication programme. These changes have allowed the University of Auckland to run this scenario in larger class settings (e.g., can now accommodate up to 40 students), teach cutting-edge science based on recent eruptions, and further emphasise science communication best practices. In this presentation, we will summarise the new changes in detail and explain how they affect the exercise. We will also briefly describe the pared-down, virtual version we ran on Zoom in 2020.

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Home-brewed volcanoes: Virtual outreach during lockdown

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The Determining Volcanic Risk in Auckland (DEVORA) research programme's outreach calendar generally includes several large events and school visits every year. In 2020, many of these events were cancelled due to COVID-19. When the DEVORA outreach team began looking for virtual ways to connect with the local community, we found that our standard outreach activities were rarely documented online. To fill this need, we have developed a two series of videos, one each for students and educators (including both parents and teachers), that detail our typical activities. The student series of videos provide some background and demonstrate the experiment; these short videos each feature one experiment. Since these videos are analogous to our in-person demonstrations, a student can perform most of the experiments with little to no supervision at home as almost none of the experiments require specialised materials. We hope that this provided students learning from home an educational and fun way to break up online learning. The educator series of videos provides more background and focuses on showing educators how they could implement multiple of the experiments together in a larger lesson. The aim of this series is to empower educators so that they are comfortable engaging with and teaching volcanology and earth science more broadly, especially as the majority of students in New Zealand could be impacted by a future volcanic eruption. In this presentation, we introduce the developed videos, describe the response we have received, and discuss how the videos will affect our outreach plans moving forward. Although these videos were created in response to COVID-19, we are working towards incorporating them into our long-term outreach plans. In the future, we envisage the videos helping us larger, and potentially different, audiences than previously possible and potentially open avenues for new collaborations.

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Urbanisation and lava flow advancement: How the presence of buildings influences lava flow areal footprint modelling

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4B: Hazards, C2, November 24, 2020, 8:30 AM - 10:30 AM

Bare earth digital elevation models (DEMs) are almost always required when simulating volcanic hazards and have been identified as a key input parameter when creating ground-hugging volcanic flows' areal footprints [1, 2]. However, modelling of 2005 Panabaj (Guatemala) lahars from Toliman Volcano indicates that the areal footprints of ground-hugging flows can be influenced by the presence of superficial features [2] – which are not represented in a DEM. In this presentation, we explore how lava flow areal footprints differ when modelled on a DEM versus when modelled on a digital surface model (DSM) using a hypothetical case study in the Auckland Volcanic Field [1]. Additionally, we present two comparison metrics to aid the modeller when selecting an areal footprint for further work. We find that modelling on a DSM substantially alters the resulting areal footprint in areas heavily modified by humans, and also noticeably decreases the flow's runout length. This is despite relatively minimal differences in the simulated areal footprints' median and mean thicknesses. This difference in outputs highlights the importance of considering surficial features when creating estimates of future areal footprints of lava flows in some cases. When creating future lava flows' areal footprints, it is important to note that a typical DSM includes both relatively invulnerable and vulnerable features. Thus, some features included in a DSM may not survive to the end of the eruption. To create a DSM with only relatively invulnerable features, specialised processing and considerable asset data is needed. While potentially only interesting in some cases, modelling on a DSM with only relatively invulnerable features may provide different insight for assessing potential damage.

[1] Tsang et al. (2020) The influence of surficial features in lava flow modelling. JAV 9:6.
[2] Charbonnier et al. (2017) Modeling the October 2005 lahars at Panabaj (Guatemala). BV 80:4.

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A granite in the Otago Schist: Caravel-1, offshore north Otago

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7A: Volcanism, C1, November 25, 2020, 8:30 AM - 10:30 AM

Offshore hydrocarbon exploration well Caravel-1 well lies c. 70 km east of Palmerston, at the head of the Bounty Trough. Predicted basement here is Otago Schist. However, at TD of 2692 m the well bottomed in 30 m of mylonitic medium-grained two-mica granite that seismic data suggests may have a horst-like lateral extent of tens to hundreds of sq. km. Geophysical and image logs collected across the 30 m thick section of granite confirm the pervasive nature of a fabric consistent with regional tectonism. U-Pb monazite dating indicates a primary crystallisation age of 95 ± 3 Ma, approximately 10 Ma younger than the youngest Western Province continental margin arc granites that currently lie 250 km to the south. Whole rock chemistry and Sr and Nd isotopes are consistent with bulk melting of schist of Torlesse parentage; the granite has no alkaline or clear A-type features. K-feldspar and muscovite 40Ar/39Ar thermochronology indicates rapid cooling and tectonic exhumation at c. 91 Ma. We interpret the crystallisation and exhumation ages to possibly indicate formation of the Bounty Trough at 95-91 Ma, an age which overlaps exhumation on the Sisters Shear Zone detachment of Stewart Island. Heat for crustal melting could have been supplied by asthenospheric mantle rising within the Bounty Trough rift axis. The Caravel granite and nearby c. 91 Ma granulitic lower crust sampled by diatremes at Kakanui together indicate Late Cretaceous high-grade metamorphism and crustal melting under the southern Canterbury Basin. Late Cretaceous metamorphic core complex-like features have now been reported under and/or adjacent to five Zealandia sedimentary basins: Taranaki, West Coast, Western Southland, Great South and Canterbury.

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Concentrated gas hydrate deposits in thrust-related anticlines: insights into their evolution and assessment of hydrate volumes from the southern Hikurangi Margin

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3A: Unravelling the Seascape, C1, November 23, 2020, 4:00 PM - 5:30 PM

High amplitude seismic reflections congruent with high seismic velocities within the gas hydrate stability zone are considered an indicator of sediments bearing gas hydrate in high concentrations. The analysis of densely spaced 2D reflection seismic data from the southern Hikurangi Margin allowed the identification and mapping of concentrated hydrate deposits in the core region of Glendhu and Honeycomb ridges, two thrust-related anticlines lying at the toe of the accretionary wedge. Upward gas migration along steeply dipping strata that cross the base of gas hydrate stability beneath the ridge crests supplies methane for hydrate formation. We suggest that the vertical extent of these deposits is a function of the maturity of the ridge and of the volume of sediments from which fluid can flow into each structure.

To quantitatively characterize these deposits, we apply a two-step statistical based seismic and petrophysical inversion of multi-channel seismic data that includes a rock physics model for gas hydrate-bearing marine sediments. We find that the hydrate saturation locally exceeds 40% of the pore space at Glendhu Ridge and 60% at Honeycomb Ridge. The predicted petrophysical properties and the estimated spatial extent of the deposits allow a first order assessment of total gas hydrate in place in these two reservoirs. Glendhu and Honeycomb ridges contain, combined, nearly 1 million m3 of gas hydrate, which makes this region interesting for further research into seabed ecology, ocean chemistry and energy resources.

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Urban greenhouse gas emission response to COVID-19 shutdowns in New Zealand and North America

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5C: Climate, C3, November 24, 2020, 11:00 AM - 1:00 PM

COVID-related shutdowns resulted in dramatic reductions in traffic and to a lesser extent other anthropogenic emission sources. Globally the change in emissions, although substantial, will be challenging to distinguish from the large and varying greenhouse gas background signal. In contrast, greenhouse gas emission changes are expected to be more readily detectable in urban areas, due to the concentration of emissions from cities.

Here we present results from greenhouse gas observation networks across Auckland, Wellington and six North American cities. The North American cities have all been instrumented for greenhouse gas measurements for several years including through the COVID shutdown period, with each city having similar but slightly different experimental configurations. We examine multiple observational analysis methods to evaluate the timing and magnitude of emission changes. The ratio of CO2:CH4 indicates a 10-20% drop in CO2 emissions in most cities. Cumulative enhancement analysis allows us to detect the timing of the abrupt emission decline, and our results are consistent with traffic data and government directives.

In New Zealand, our long-term network was not yet installed and travel was very limited during Level 4 lockdown, so we used novel techniques to detect emission changes. We initiated a citizen scientist project, the Great Greenhouse Gas Grassoff, in which grass samples were collected at sites all around New Zealand throughout the lockdown. Radiocarbon (14C) analysis allowed us to determine the daytime weekly mean fossil fuel CO2 mole fraction at each site. Urban roadsides show emission reductions of ~80% during Level 4 lockdown at most locations.

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Hiding Behind an Obstacle? Probing the Hazard Impacts Inside Pyroclastic Currents Across Topographic Barriers

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4A: Volcanism, C1, November 24, 2020, 8:30 AM - 10:30 AM

Pyroclastic currents (PCs) are amongst the most lethal and destructive volcanic phenomena known. Their hazard impacts arise as a combination of the PCs' high velocity, high temperature, high dynamic pressure and ash load. How these properties vary spatiotemporally inside flows remains unknown due to the lack of direct measurements into real-world flows. This means that volcanic hazard models are plagued by large uncertainties and cannot yet be validated robustly. Here we present the results of new sets of large-scale PC experiments simulating flow propagation over topographic obstacles. Using the eruption simulator facility PELE, we synthesize PCs that dynamically and kinematically scale events like the 2012 Te Maari and 2019 Whakaari eruptions. We directly measured time-series of velocity, temperature, flow density and dynamic pressure of the evolving flow in nine vertical sensor profiles spread across the 35 m long flow runout. By using high-speed, normal light, and thermal infrared cinematography in combination with extremely fast temperature and dynamic pressure sensors we show that velocity, dynamic pressure and heat impacts occur in the form of regular internal waves that perpetuate downstream. Through cross-correlation, we track these hazard pulses over obstacles and downcurrent and show that their internal velocity exceeds that of the flow front manifold. We also show that topographic obstacles disturb the local gravity current structure locally and produce spectacular current detachment structures, as well as low-pressure and low-temperature sweet spots immediately behind obstacles momentarily. However, current re-attachment and turbulence-induced velocity, pressure, and temperature pulsing re-establish quickly behind the obstacle. As a consequence, the dangerous pulsing of destructive dynamic pressure, burning heat and suffocating ash-load perpetuate effectively during flow evolution and characterize the majority of the PC hazard footprint. The results of this study have implications for re-defining and zoning hazard impacts from pyroclastic currents and the design of PC-proof shelters.

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Marlborough Fault System: topographic fabric of a complex 4D transition zone in central New Zealand

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6B: Transition Zone, C2, November 24, 2020, 2:30 PM - 4:30 PM

In active regions the landscape is a result of interaction between tectonic and geomorphic processes. Faulting influences topographic development by (1) creating constructional topography through tectonic uplift/subsidence and (2) locally weakening bedrock that is preferentially eroded or incised to create erosional topography. Therefore, topographic fabric contains information about tectonic setting and tectonic history.

The Marlborough Fault System (MFS) is the present-day transition from subduction along the Hikurangi margin to oblique continental collision along the Alpine Fault. The MFS varies both along and across strike with depth and in time. It is a complex 4D transition where the crustal structure reflects regional differences in tectonic history, crustal transfer from one plate to another is occurring and at depth a subduction interface is developing within a previously intact plate.

Analysis of MFS topographic anisotropy at a variety of variety of scales (Roy et al. 2016) and comparison of inactive faults, active faults and river segments (Duvall et al. 2020) show a change in the topographic fabric from west to east within the MFS. In the west a strong NNE/SSW fabric, associated with inactive faults, is truncated against an ENE/WSW fabric associated with active faults. The river network largely follows the inactive fault trend. In the east, the topographic fabric is dominated by long ENE/WSW-striking structures with both inactive and active faults as well as the river network conforming to this orientation. We unravel the topographic of the MFS from west to east and show how the different tectonic histories are preserved in the landscape of the region.

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A brief history of the GeoEd SIG

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8A: Geo-Teaching & Practice, C1, November 25, 2020, 11:00 AM - 1:00 PM

A Brief history of the Geoscience Education SIG (1983-2020)

This short contemporary history sets the scene and briefly summarises the key events in the evolution of what is today the Geoscience education, outreach and international development special interest group; GeOID. An analysis of all GSNZ newsletters and private correspondence indicates the formation of the SIG in the early 1980s was largely in response to appeals from secondary school teachers for resources. There are 151 Geological Society Newsletter issues and as at November 2020, 32 Geoscience Society Newsletter issues giving a total of 181 Newsletters since 1954. Some 41% of all newsletters have some kind of entry concerning geoscience education. The first reference to geological education was in May 1960 (p10-11) when Harold Wellman and Prof. Bob Clark of Victoria University of Wellington discussed degree structures and a suggestion by a Mr Bruce that geology become a subject at secondary school. The next reference to geological education was a letter to the editor by Glenn Vallender in 1981 asking for resources for community evening classes in geology – a 21-year hiatus! New data is presented showing the continued gap in the numbers of students learning geoscience. The challenge for the GeOID SIG (and its successors) is to support the narrowing of this gap.

…….. "many students leave school with misconceptions and misapprehensions about the relevance of Earth Science and the importance of Earth Science education. These attitudes perpetuate the narrow perspectives of reductionist policy makers in education, including politicians, scientists, and educators, with the result that there has been no appreciable change in the profile of Earth Science in schools, or in the way that it is taught".
Orion, N. (2019). The future challenge of Earth science education research. Discip Interdscip Sci Educ Res 1, 3.

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New fossil wood from Zealandia and its use in reconstructing paleoclimate

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5C: Climate, C3, November 24, 2020, 11:00 AM - 1:00 PM

Angiospermous and gymnospermous fossil wood from the Chatham and Auckland Islands and 13 South Island sites is investigated. Samples range in age from Permian to Miocene and include materials from lignite, conglomerate, sandstone, silcrete and greensand. Gymnosperms include Araucarioxylon (Permian to Miocene) and Planoxylon (Jurassic to Cretaceous), although Permian specimens identified as 'Araucarioxylon' from Southland probably represent wood of the seed fern Glossopteris. New Eocene-aged legume wood from Boulder Hill, near Dunedin occurs at a key time of divergence time for Leguminosae. Miocene-aged Araliaceae-like wood from the Auckland Islands is the first record of its type from the Southern Hemisphere.

Identification of wood from forest trees and shrubs provides a new tool for reconstructing Zealandia's floral diversity and paleoclimate through time. Once identified, a multivariate anatomical analysis (MAA) based on angiospermous wood physiognomy is used to estimate climatological variables including mean annual temperature (MAT), mean annual range in temperature (MART) and mean annual precipitation (MAP). 22 MAA equations determined from overseas studies are evaluated using the cellular morphology of 65 extant New Zealand species. The results are highly variable: MAT outputs range from 0.4 °C to 33.9 °C with an average MAT of 18.2 °C. The MAT for modern New Zealand is ~13 °C. Possible reasons for this discrepancy include the abundance or absence of certain wood features (90% of species in the New Zealand flora have vessels <100 µm, none have storied rays, all have axial parenchyma), habitat restriction due to New Zealand's small size and limited latitudinal range, or the retention of relictual wood features from the much warmer Miocene. The equations are then used to calculate Miocene climate variables (the only period with >10 angiospermous morphotypes), resulting in an average MAT of 12.9 °C (range 7.7 °C to 22.6 °C), similar to that of modern New Zealand.

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Meteoric ground ice in mid-Miocene permafrost: a paleo-temperature proxy, upper McMurdo Dry Valleys of Antarctica

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2C: Cryosphere, C3, November 23, 2020, 1:30 PM - 3:30 PM

During the 2016 Friis Hills Drilling Project (77°45'S, 161°30'E), sediment cores were retrieved from mid-Miocene permafrost (ca. 14-15 Ma), which was the last time global climate averaged 3 – 5°C warmer than present and tundra-like ecosystems were present in Antarctica. These cores contain a unique cryostratigraphic assemblage with ground ice present to depths of 50 m. This provides a rare opportunity to study ground ice encased within Miocene-aged sediments. Two ice lenses, 2- and 15-cm thick, were found at 37 and 43 m depths, respectively. These ice lenses lie below the depth of zero thermal amplitude, and their isotopic signature suggests that they originated from the freezing of meteoric water following the deposition of the sediments during the mid-Miocene. Ground ice with a $\delta^{18}O$ composition that preserves a meteoric signature, can be used as a paleo-temperature proxy. Here, we compare the average $\delta^{18}O$ composition of the ice lenses (–34.6 ± 1.2‰) to ice core from Taylor Dome. We also propose a temperature correction based on $\delta^{18}O$ of benthic foraminifera during the mid-Miocene and paleogeography. Temperature reconstructions based on the corrected $\delta^{18}O$ value of the deep ground ice suggest that the mid-Miocene was ca. 6-11°C warmer; conditions that are comparable to those found in the modern Arctic, such as in west Greenland.

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From Edgecumbe Earthquake to today: how the initial paleoseismic studies in the Taupō Rift have shaped our understanding of active fault behaviour in the rift

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9B: Active Tectonics, C2, November 25, 2020, 2:30 PM - 3:30 PM

The complex and fascinating active faulting history of the northern and central Taupō Rift started to be revealed with the paleoseismic studies following the 1987 Edgecumbe earthquake by Beanland et al. In the northern Taupō Rift, Berryman et al. furthered these studies on the Matata, Rotoitipakau, Ngakuru, Whirinaki, Ngapouri and Paeora faults (1987-1997). These studies addressed a range of objectives that have been further developed to date, including: the first geologically derived extension rates of the rift; demonstrating extreme variability in fault slip rate, co-seismic displacement and earthquake recurrence through time; normal fault growth in a dense fault network; setting up an approach for fault source characterisation for the rest of the Taupō Rift that is still used in the current National Seismic Hazard Model; and identifying paleo-volcano-tectonic interactions. All these outcomes would have not been possible without the thorough understanding of the Late Pleistocene to the present volcanic stratigraphy that started with Ian Nairn's work (1981).

In the central Taupō Rift, the paleoseismic history is still poorly developed but pioneering studies to assess seismic hazards on the Waikato River hydro dams, led by Berryman (1991-1994), planted the seed for a better understanding of the spatial and temporal evolution of active faulting in the rift (2017), and the special definition of an active fault for hazard purposes in this extensional domain (2016). Again, volcanic stratigraphy and mapping studies, compiled by Leonard et al (2010) and earlier workers, have been invaluable in nailing down the timing of fault activity. For the Late Pleistocene to present period, detailed volcanic stratigraphy and physical volcanology studies initiated by George Walker and Colin Wilson (1980-1993) are providing the basis for current development of paleoseismic studies and related stress and strain relationships between volcanoes and faults.

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Historical seismograms - Preserving and utilising a unique 100-year continuous record of New Zealand earth observations

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4B: Hazards, C2, November 24, 2020, 8:30 AM - 10:30 AM

As part of the nationally significant Earthquake Information Database, GNS Science maintains a unique, non-repeatable record of New Zealand seismicity dating back over 100 years. These original paper seismograms were recorded from 1900 to 2005, cover all of mainland New Zealand, extend to the Pacific Islands and Antarctica and consist of over 1,000,000 individual records.

The history of instrumental seismology is short in comparison to seismic and tectonic cycles, which results in a relative scarcity of records for historical large earthquakes. This limits our ability to re-analyse historical events with modern analytical techniques. GNS Science is undergoing a process to digitise this collection, collaborate with external researchers and ensure that this unique dataset is available in a time of significant advances in seismology due to breakthroughs in big data techniques.

Overseas data mining of historical seismological data sets is enabling novel discoveries and cross-disciplinary research across the earth sciences. To aid in this effort locally we will summarise the extent of the collection, highlight some of the major New Zealand eruptions and earthquakes only recorded on analogue media and propose some possible research uses for the collection, with the aim to encourage discussions across discipline and ultimately safeguard this resource through its utilisation.
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Componentry and textural characteristics of pyroclasts from the Taupo 232 CE Y2 eruption – implications for conduit dynamics and eruption evolution.

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5A: Volcanism, C1, November 24, 2020, 11:00 AM - 1:00 PM

The Taupo Volcanic Zone is one of the most frequent producers of Plinian eruptions globally. The dispersal and sedimentation of pyroclasts in Plinian eruptions pose significant environmental and societal threats. Therefore, further understanding of the dynamics of these volcanic events is essential for hazard planning and decision making for many volcanoes across the globe. Here we present the results of a study that examined three comprehensively sampled tephra profiles of the Y2 plinian fall deposit, from the Taupo 232 CE eruption, to characterise conduit processes immediately prior to fragmentation and to reconstruct spatiotemporal variation in umbrella cloud sedimentation. A combination of grain-size, componentry and clast density measurements, as well as microscopic analysis of juvenile pyroclast textures and petrographic analysis of foreign lithic components were used to define syn-eruptive chronostratigraphic time markers. The chronostratigraphic time markers allow reconstruction of the spatiotemporal deposition and time-variant source conditions. This data can be used in future computational studies as a real-world test for the validation of plume and ash-dispersal models. The juvenile components were grouped into five distinctive textural classes which showed a systematic increase in clast density and shear deformed bubbles and glass, as well as absence or occurrence of microlite crystallization. From this, a tentative conduit model for the time immediately prior to magma fragmentation was developed to explain the strong horizontal gradients in magma density and estimate radial extents of the variably vesiculated and shear-deformed proportions of the magma. These results show that componentry and textural pyroclast data can be usefully combined to reconstruct strong lateral gradients in the conduit with regards to magma vesiculation, bubble coalescence and permeability development.

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Petrophysical properties of pyroclastic rocks – Case-study in the Yingcheng Formation, Songliao Basin, China

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Volcanic rocks can host economically important fluids (e.g. hot water, hydrocarbons, CO2). Pyroclastic rocks of the Yingcheng Formation are one of the most prolific hydrocarbon reservoirs of the Songliao Basin, northeast China. Based on a large dataset of 485 core samples from the Yingcheng Formation, we investigate the geological parameters that control the fluid-flow properties of pyroclastic rocks. To characterize their pore structure we use information from a range of techniques, including analysis of thin-sections and scanning electron microscope images, and mercury injection capillary pressure tests. We develop numerical models for the flow properties of welded and unwelded pyroclastic rocks using parameters such as the morphology, size and connectivity of each type of pore structure. Our data and models suggest that matrix intergranular pores and vesicles primarily control the porosity, while permeabilities of up to 2 mD are mainly controlled by the interconnection of matrix intergranular pores. Fragmentation, gas content, intensity of welding and burial depth of pyroclastic rocks play critical roles in the porosity and permeability of volcanic reservoirs. Post-depositional burial decreases the permeability and porosity of unwelded rocks and increases the permeability of welded pyroclastic rocks. At >2500 m depth, for example, welded pyroclastic rocks typically have 10-100 times the permeability of similar rocks at the surface. This increase in permeability is attributed to the formation of microfractures during burial and progressive vertical loading, which connect pre-existing intergranular porosity (pores and vesicles). This study demonstrates that reservoir properties are controlled by both primary (i.e. syn-depositional) and secondary factors (i.e. post-deposition).

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Velocity variations in the northern Hikurangi margin and their relation to slow slip

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Slow slip events (SSE) extend our understanding of subduction behaviour, but are difficult to observe offshore where they are most common. The Northern Hikurangi margin has the advantage of documented SSE events at relatively shallow depths, as well as onshore and offshore seismic sensors to collect crucial data. The behaviour of SSEs and how they influence, or are influenced by, the physical properties of surrounding materials are open to question. Monitoring velocity changes before, during and after SSEs provides opportunities to study the slow earthquake behaviour and its relation to the changes of the physical properties of subsurface materials.

From May of 2014 to June of 2015, for the project "The Hikurangi Ocean Bottom Investigation into Tremor and Slow Slip (HOBITSS)", 15 OBSs were deployed offshore Gisborne on the Hikurangi margin. During this period, there were four main SSEs, with the second in October 2014, in particular, producing significant slip. Ambient noise data from the OBSs are used to study seismic velocity changes related to these SSEs. Single station cross-component correlations are computed. Coda waves retrieved from cross correlations are used to compute velocity changes at a frequency range of 2.5-14 s. At these frequencies we focus on the upper plate. The velocity changes averaged from used nine OBSs display a 0.06% velocity decrease during the largest SSE in October, followed by a 0.07% velocity increase after. This suggests a fluid increase in the upper plate during the SSE followed by a fluid decrease. We propose that fluid migrated from the lower plate into the upper plate as a result of the SSE breaking the fluid reservoir seal on the plate interface, causing a velocity decrease in the upper plate. After the SSE, the fluid in the upper plate spread away and the velocity increased.

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Spatial heterogeneity in microseismicity and stress near transitional segment boundaries on the Alpine Fault

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

The size of an earthquake and the character of the seismic radiation it produces are strongly controlled by the length of the fault that slips, yet this is rarely the full length of a fault's surface exposure. Understanding the on-fault processes influencing eventual rupture length is an ongoing challenge in earthquake science. Extensive paleoseismic studies along New Zealand's Alpine Fault have shown that large (M7+) earthquakes occur remarkable regularly, every 291+/-23 years, but typically rupture different combinations of fault segments. Specifically, ruptures often terminate at the South Westland and Central segment boundary, near Haast, and near the Central and North Westland segment boundary near Inchbonnie at the intersection with the Hope Fault. However, some ruptures propagate through these boundaries in multi-segment events, increasing the earthquake magnitude from M7+ to M7.8+.

To understand the transitional behaviour of these segment boundaries, and their role in conditionally halting through-going ruptures, we quantify spatial heterogeneity in factors which have elsewhere been proposed to influence rupture arrest, using the locations and physical properties of small earthquakes. Using micro-earthquake catalogues from new and existing dense seismic networks we map along-strike variations in seismogenesis including: seismogenic depth, on-fault seismic slip, triaxial stress field orientations, aseismic fault patches, fault geometry/structure and connectivity with intersecting faults. We present results of the geometry and mechanical state of these complex rupture barrier regions near the Hope-Alpine transition at Inchbonnie, and the Alpine-Puysegur transition south of Haast, and discuss their contrasting behaviour with the more uniform central Alpine Fault segment in the context of large-scale rupture processes.

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Using unsupervised machine learning to identify changes in eruptive behaviour at Mount Etna, Italy

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

Volcanoes frequently generate infrasound signals that need to be processed before they can be used to monitor and track changes in eruptive activity. Unsupervised machine learning is complementary to existing processing methods and can be used for data exploration to identify features of interest in the data. Here, I examine three days of infrasound data from Mount Etna, Italy, that encompasses the 24 December 2018 fissure eruption. The continuous infrasound data is divided into overlapping windows and for each window I extract seven features in the time and frequency domains that characterize the signal. I apply the k-means clustering algorithm to group the data into seven clusters and generate a discrete time series of cluster labels. The cluster labels clearly identify a change in eruptive activity from Strombolian explosions at the summit to lava fountaining at the fissure. Feature distributions and representative waveforms for each cluster are analyzed and source mechanisms are hypothesized. This work illustrates how advances in unsupervised machine learning can be leveraged to explore volcano infrasound data sets and demonstrates the potential of these techniques for monitoring eruptive activity. Here, I focus on volcano infrasound observations but unsupervised clustering algorithms such as k-means are general processing tools that can be used to analyze other geophysical data such as seismic and geodetic data or continuous gas measurements.

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What we do in the shallows: Natural and anthropogenic seafloor geomorphologies in a drowned river valley, New Zealand

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2A: Unravelling the Seascape, C1, November 23, 2020, 1:30 PM - 3:30 PM

The shallow marine environment represents a region of high biological productivity, ecological diversity, and complex oceanographic conditions, and supports various human activities and industries. Mapping the seafloor in shallow marine environments reveals features in detail, shedding light on a range of natural and anthropogenic processes. We present a high-resolution (2-m) multibeam dataset, combined with geologic samples that reveals a complete map of the seafloor from the land-water interface to ~350 m water depth within Queen Charlotte Sound/Tōtaranui (QCS) and Tory Channel/Kura Te Au (TC), Marlborough Sounds, New Zealand. These data reveal that the seafloor geomorphology and distribution of natural and anthropogenic features varies spatially from the inner QCS to the Cook Strait. Tidal currents play a large role in the erosion, transport, and deposition of sediments in QCS and TC. The distribution and depth of seafloor scouring suggests that tidal flow is locally intensified by coastal geometry and bathymetric barriers, resulting in concentrated scouring. In addition, superimposed bedforms reflect localised variations in flow direction that have likely developed across a range of spatial and temporal scales.

Evidence for extensive seafloor fluid expulsion is preserved in >8500 pockmarks predominantly within the inner and central QCS. Pockmark size and spatial distribution suggests multiple fluid sources in the region. The cumulative anthropogenic footprint within QCS represents 6.4 km2 (~1.5%) of the total seafloor area and is related to maritime activities including anchor dragging and mooring blocks.

This study reveals a range of natural and anthropogenic seafloor geomorphologies, providing an example of the information that can be revealed by comprehensive multibeam mapping from the land-water interface to the subtidal zone. Results presented in this study form a robust basis upon which to develop improved hydrodynamic models and benthic habitat maps and to assess the anthropogenic impact in the shallow marine realm.

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Answering to stakeholders: Sensitivity of liquefaction hazard during earthquakes to sea-level rise in the San Francisco Bay Area, California

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4B: Hazards, C2, November 24, 2020, 8:30 AM - 10:30 AM

The U.S. Geological Survey has engaged with San Francisco Bay Area (SFBA) stakeholders about an earthquake scenario (HayWired) and a Coastal Storm Modeling System (CoSMoS). In the SFBA, 1 meter (m) of sea-level rise (SLR) is projected to occur in 40 to 80 years time and cause overland flooding and groundwater table shoaling. Planners and engineers asked: where and how could the liquefaction hazard during an earthquake change with ground water rise?

Liquefaction surface effects, including sand boils, surface cracking, vertical settlement of the ground surface, and lateral spreads, may damage foundations and buried infrastructure. Scientists assessed the effects of SLR on the liquefaction hazard by computing changes in the liquefaction potential index (LPI) over 400 Cone Penetration Test (CPT) borings around the bay using two groundwater table models developed for SLR up to 5 m. Ground shaking at boring locations is represented by two earthquake scenarios, a M 6.5 earthquake with uniform 0.25 g peak ground acceleration (PGA) and the M7.0 Hayward fault (HayWired) scenario with PGA between 0.20 and 0.95 g. While the majority of sites are insensitive to sea-level changes of less than 1 meter, some site conditions are highly sensitive to small changes in water levels, and the potential for liquefaction damage at most sites increase with large shifts in sea-level (> 3 m). At 1 m of SLR, most of the locations with the largest LPI changes are found in artificial fill over estuarine mud.

We tested two communication products with SFBA stakeholders: (1) figures of LPI change at sites from SLR using two groundwater models, two tidal datum and three hydraulic conductivity values and (2) maps of median LPI change. This project illustrates a scientific investigation conducted in parallel with stakeholder engagement including usability testing to guide the development of scientific products for practitioners.

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Detecting and quantifying magmatic tracers in spring waters on Mount Taranaki Volcano, New Zealand

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The geochemistry of spring waters can provide valuable information about subsurface magmatic conditions at dormant volcanoes. Temporal changes in fluid chemistry can potentially provide important insights during the reawakening of such volcanic systems. At Mount Taranaki volcano in New Zealand, which last erupted in 1780-1800, cold mineral springs emerge on the flanks of the volcano typically between 1.5 to 5 km from the summit, and at least one warm spring (29°C) occurs ~13 km distant on the outer flanks. Two of the springs were sampled in 2020 for the first time in 30-40 years. The chemistry of the cold spring high on upper flanks of the volcano was largely unchanged since the last sampling campaign, indicating a stable reservoir likely feeds this mineral spring. The water was 5°C with a pH of ~ 5.5 with carbonic acid as the dominant anion. The waters are rich in Fe and Mg due to the dissolution of volcanic rocks by the acidic water. The $\delta^{13}C$ of the dissolved inorganic carbon (DIC) was -5.2 per mil vs. VPDB, suggesting a magmatic source for the CO_2. CO_2 concentrations in air samples, collected several meters from the spring source, were also several hundred ppm above background with minor amounts of H_2S detected. Concentrations of Cl, SO_4 and SiO_2 were low, indicating no hydrothermal component in the spring water. Helium isotopic analysis and tritium dating the waters as well as chemistry of the thermal spring are underway. This study is the first step in a comprehensive plan to estimate the amount of volcanic volatiles released by individual springs, and develop baseline data from Mount Taranaki to underpin future assessment of volcanic unrest. Eventually this study aims to build a better conceptual model of the ongoing rock alteration and the deep magmatic system at Mount Taranaki.

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Susceptibility Factors Controlling the Occurrence of Slow-Moving Large Landslides in the Whanganui Basin Sediments, North Island

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4C: Sediments, C3, November 24, 2020, 8:30 AM - 10:30 AM

Within the Whanganui Basin sediments of the southern North Island, slow-moving large landslides present a hazard for infrastructure and contribute fine sediment to waterways. Updates to New Zealand's national policy statement for freshwater management necessitate an accurate accounting of freshwater sediment sources, but current sediment budget models do not account for slow-moving large landslides. Also, the factors that influence the occurrence and activity of these landslides are still poorly constrained. To better understand the prevalence and factors that cause these landslides to occur, we have mapped over one thousand relict and active large landslides within the Whanganui Basin sediments that range in size from two to five hundred hectares. This landslide inventory is being combined with a suite of over twenty geologic, geomorphic, and climatic variables in a logistic regression susceptibility analysis to determine which factors control landslide occurrence. In addition, partitioning of the landslide dataset by type and size is being used to determine if the influence of susceptibility factors vary among the morphologies. Initial findings show a strong influence of fluvial incision in controlling the regional distribution of the landslides, consistent with the few local case studies of landslides in this region. Improving the health of New Zealand's waterways is an important goal and a better understanding of the sediment contributions of slow-moving large landslides will help direct future management efforts.

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Assessment of tsunami source complexities at the Northern Tonga Trench and comparisons with local tsunami source potential at the Southern Hikurangi margin

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6B: Transition Zone, C2, November 24, 2020, 2:30 PM - 4:30 PM

The Tonga Trench subduction zone has the highest convergence rate in the world but limited observations of its tsunami potential. Rupture complexities at the northern terminus of the Tonga Trench, with its tightly curved, hook-like morphology, involve both normal and reverse fault mechanisms which appear to increase the potential for tsunamis that are much larger than would be otherwise expected. Indeed, the 2009 Mw 8.1 earthquake involved the near-simultaneous rupture of both outer-rise normal and intraplate reverse faults, and generated a major local tsunami that impacted the Samoan Islands and northern Tonga. Here we use numerical modelling, instrumental and surveyed observations of runup and sediment signatures to study the 2009 event from initiation to inundation in Independent Samoa to better understand the contribution of source complexity on the tsunami effects. Sediment signatures of the 2009 tsunami were largely confined to the southern and southeastern coasts of Upolu and Savaii Islands, respectively, with the highest runup of 14m recorded on southeast Upolu. Findings suggest that at least three near-simultaneous ruptures occurred at the source which exacerbated tsunamigenesis and subsequent impacts. Comparison of the spatial distributions of older tsunami deposits, which are interpreted to be of local origin (including the 1917 predecessor), with deposit distributions of the 2009 tsunami, suggest a potentially larger event occurred ~300 ya. We infer that the source for this likely event was in the hook-like region of the Tonga Trench between the 1917 and 2009 epicentres; and may have also involved complex outer-rise and intraplate near-simultaneous ruptures. These observations are discussed in relation to recent tsunameter deployments in the Southwest Pacific and 'worst case' tsunami models along the Tonga-Kermadec-Hikurangi margin. Comparisons between the northern Tonga Trench with its curved morphology and the southern Hikurangi Trench are discussed within the context of local tsunami hazard source potential.

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Paleoclimate Reconstruction of Orepuki-1 Sedimentary Drill Core: Initial Results

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Equilibrium climate sensitivity (ECS) describes the amount of warming Earth will experience in response to a doubling of PCO2. The IPCC's Fifth Assessment Report (2014) concluded that the ECS is "likely to lie in the range of 2°C to 4.5°C, with a most likely value of about 3°C". Geological paleoclimate reconstructions constrain the range and reduce the uncertainty of the ECS. During the Eocene Climatic Optimum, atmospheric CO2 levels are thought to have been between 600 and 1000 ppm and mean annual surface air temperature may have been 6-8°C warmer than today. This project aims to reconstruct the climate setting of Southland, New Zealand from the 200 m long Orepuki-1 sedimentary drill core. The Orepuki-1 is divided into four units which were deposited in a variety of settings ranging from terrestrial to marine environments. The basal Beaumont Formation (Eocene) consists of coal-bearing terrestrial and freshwater sediments, which are unconformably overlain by Landon Series (Oligocene) brown sandstones with green sands and lenses of concretionary limestone. Unconformably overlying this is Wanganui Series (Pliocene – Early Pleistocene) bedded yellow sandstones, carbonaceous mudstones and woody lignites, which are overlain by a series of Pleistocene coastal and river terrace gravels. Pilot paleomagnetic analyses indicate a reliable detrital remanent magnetisation (DRM) and high resolution (2 cm) magnetic susceptibility data contain prominent cycles. Future work will focus on constructing a magnetostratigraphic age model and time series analysis of magnetic susceptibility data to determine if orbitally paced cycles are present. Sea surface temperatures will be reconstructed from marine sediments using TEX86 lipids and alkenone biomarkers and from long chained diols for freshwater sediments at the University of Otago Centre for Organic Geochemistry with the aim of identifying the peak temperatures during the Eocene Climatic Optimum.

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Multiproxy speleothem records from Aotearoa New Zealand map latitudinal shift of westerly winds across the Early Holocene

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6C: Climate, C3, November 24, 2020, 2:30 PM - 4:30 PM

Terrestrial paleoclimate records from the Southern Hemisphere attain special significance due to their relative scarcity. This holds true for New Zealand speleothem archives, which have provided clues to past dynamics of Southern Hemisphere westerly winds in the Pacific as well as the associated changes in ocean currents, temperature, and rainfall. The difficulty in interpreting commonly utilized stable isotope (δ18O and δ13C) proxies in speleothems, which may respond to numerous controlling processes, creates a need for speleothem proxy records with more straightforward interpretations. Local hydrology and rainfall amount are often major influences on speleothem trace element ratios (Mg/Ca, Sr/Ca, and Ba/Ca) and the calcium isotope system (δ44/42Ca, a relatively new proxy) via the prior calcite precipitation (PCP) mechanism. Since PCP increases (decreases) during dry (wet) periods, these proxies may reveal past rainfall changes that allow the reconstruction of local hydrology and better assessment of stable isotope controls at a given study site. In order to develop a robust interpretation for multiproxy speleothem records from New Zealand, we present new trace element, δ44/42Ca, and stable isotope time series from three caves across a large latitudinal gradient: Waipuna Cave in the Western North Island, Hodges Creek in the Northwestern South Island, and Dave's Cave in the Southwestern South Island. Correlations between Mg/Ca and δ44/42Ca in our data suggest PCP control of these proxies, and our comparison of results across the three sites suggests a South-to-North sequence of increasing rainfall ~12,500 – 9,500 yrs BP. Previous studies hypothesize the Southern Hemisphere westerly winds strengthening as the latitudinal temperature gradient increased over the Southern Hemisphere from the Early to Mid-Holocene. We interpret the increasingly wet climate towards the Mid-Holocene observed in our data as evidence of the strengthening westerly winds transgressing equatorward across the length of New Zealand.

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Crustal evolution leading to successive rhyolitic supereruptions; lessons from the Jemez Mountains volcanic field, New Mexico, USA

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Poster Session 1, Mezzanine Floor, C-Block, November 23, 2020, 5:30 PM - 10:00 PM

The magmatic systems that feed supereruptions result from high magma supply from depth that sustains large regions of partial melt in the shallow crust. However, many questions remain around the processes and timescales over which supersized magmatic systems develop. Situated in rifted continental crust, analogous to the Taupo Volcanic Zone (TVZ), zircon geochemistry from the Jemez Mountains volcanic field (JMVF) in New Mexico, USA, reveals contrasting magmatic processes that led to successive rhyolitic supereruptions at 1.6 and 1.25 Ma. Before the supereruptions, zircons from lavas erupted over ~8.4 m.y. have unimodal age distributions, close to their respective eruption ages. This highlights that distinct magma domains gradually formed in the JMVF crust. Zircon crystal inheritance shows that magma from the first supereruption at 1.6 Ma included at least three of these precursor plutons and basement rock that were partially molten by enhanced magma supply from ~2 Ma. In contrast, absence of inherited zircon and a change in zircon chemistry in ignimbrite from the second supereruption at 1.25 Ma indicates a thermal resetting of the remnants of the old magma reservoir and rapid construction of a new supersized magma body. The sudden change in eruptive behaviour in the young JMVF reflects both thermal and chemical maturation of the crust, as well as elevated magma supply and partial melting of precursor plutons. Our study highlights that although crustal conditioning may occur during gradual magmatism over millions of years, the assembly of supersized magma bodies occurs over much faster timescales and may occur in succession due to thermal adjustment following magma evacuation. The 'slow boil' approach to the early crustal intrusions may be more analogous to the Tongiriro volcanic complex, while dominant young rhyolitic volcanism more accurately mirrors the high rhyolite production of the central TVZ.

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Probing mercury preservation in the sedimentary record using SEM–EDS

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Mercury concentrations and isotopes have recently gained prominence as a proxy for magmatism in deep time, particularly for large igneous provinces associated with mass extinctions, such as the end–Permian, Cretaceous–Paleogene, and end–Triassic extinctions. Measuring Hg contents in rock samples is easy and low cost, and this proxy has rapidly developed in the last decade. However, much remains to be understood about the Hg proxy, including how Hg is preserved and diagenetically processed in marine sediments. Here, we use scanning electron microscopy (SEM)–energy dispersive spectroscopy (EDS) to probe where Hg is preserved in ancient marine sediments, and infer pathways of Hg preservation in the rock record. We also present a record from a sedimentary section spanning the Triassic–Jurassic boundary, showing a full record of SEM–EDS maps from each sample, and present Hg concentration data from these samples. We discuss the utility for the Hg proxy in fingerprinting magmatic eruptions and possible next steps in investigating the Hg proxy in modern marine sediments to better understand diagenetic and preservational pathways of Hg in the sedimentary record.

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Spatial variations in seismic anisotropy in south-central North Island, New Zealand

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

Seismic anisotropy, measured through shear-wave splitting (SWS), is often considered to be an indicator of stress in the crust; however structural elements (e.g., faulting) have been shown to greatly influence anisotropy in certain regions around the world. We aim to improve our understanding of the relationship between crustal seismic anisotropy and both the stress state and geological structures across south-central North Island, New Zealand. To accomplish this, we use SWS to examine spatial variations in fast polarization azimuths and delay times. We measure SWS parameters using 20,835 local earthquakes recorded by 24 stations of the GeoNet Network (2009-2012). The resulting 42,423 high-quality SWS measurements provide us with one of the largest datasets of crustal anisotropy measurements across this region.

The spatial averaging of fast azimuths reveals significant spatial variation in direction across central North Island. We compare our local fast azimuth directions to the local stress and stress rate orientations derived from gravitational stress calculations and campaign GPS measurements, and local orientation of active faults. The directions of fast azimuth along the North Island Dextral Fault Belt (NIDFB) are generally subparallel to the regional NE-SW faults, suggesting strong structural control on anisotropy.

However, significant deviations from this structural trend are observed in three regions. Across the Wanganui Basin and the western extent of the east coast basin, the direction of fast azimuth tends to align with the regional maximum compressional stress direction, SHmax. Fast azimuth directions around Mt. Ruapehu are variable, but reflect those of both SHmax and faults, suggesting a combination of both stress-induced and structurally-controlled anisotropy. Finally, delay time spatial averaging reveals an increase in delay times east of the NIDFB, which is consistent with increased Vp/Vs values closer to the subduction interface, suggesting increasing horizontal stresses and/or crack densities towards the Hikurangi trench.

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Mafic magmatism in the Taupo Volcanic Zone, New Zealand: insights into the birth and death of very large volume rhyolitic systems

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5A: Volcanism, C1, November 24, 2020, 11:00 AM - 1:00 PM

Mafic magmatism of the rifting Taupo Volcanic Zone is volumetrically minor, but is thought to tap the material that provides the heat source for voluminous rhyolite production through partial melting of the crust. We have studied the major and trace element chemistry of mafic samples from across the entire TVZ, and the U isotopic composition of whole-rocks, groundmasses and separates of mafic mineral phases from a selection of samples. Incompatible trace element patterns indicate that there are three chemically distinct groups of samples, and that samples may be used to derive primary melt compositions. We employ the Arc Basalt Simulator (ABS5) to forward model these compositions, deriving mantle fertility, slab liquid flux, mantle volatile content, degree of melting, and P-T conditions of melt segregation. Mafic rocks erupted in areas of old, now inactive calderas constitute low-degree, deep melts, whereas those in areas of active caldera -volcanism are high-degree partial melts segregated from a less depleted source at an intermediate depth. High-Mg basaltic andesites erupted in the SW and NE point to a fertile, shallow mantle source. Our data are consistent with a petrogenetic model where mantle melting is dominated by decompression, rather than fluid fluxing, and progresses from shallow to deeper levels with time. Melt volumes initially increase to a tipping point, at which large-scale crustal melting and caldera volcanism become prominent, and then decrease owing to progressive depletion of the mantle wedge by melting, resulting in the dearth of heat provided and eventual cessation of very large volume rhyolitic volcanism. Our work, as well as melt olivine melt inclusion studies from intra- and intercaldera basalts by Barker et al. (2020, GSA Geology), demonstrate that there is a direct link between the chemistry of recently erupted mafic magmas and the long-term activity and evolution of rhyolitic volcanism in the TVZ.

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Evaluating post-depositional disturbance of distal tephra records from the 12.9 ka BP eruption of Laacher See Volcano through multidisciplinary investigations at Paddenluch and Krumpa, Germany

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4C: Sediments, C3, November 24, 2020, 8:30 AM - 10:30 AM

The Plinian eruption of Laacher See Volcano deposited a widespread tephra bed across much of Europe. Its wide dispersal and distinct geochemical signature make the Laacher See Tephra (LST) an important chronostratigraphic marker that connects the tephrochronological records of Central Europe with the North Atlantic and the Mediterranean. Distal LST occurs in chronologically consistent stratigraphic contexts but often exhibits variations in sedimentological characteristics between locations. Some sites even record multiple layers, which have occasionally been interpreted as potential precursor eruptions, thus threatening the isochron status of the LST.

To assess post-depositional processes that affect sedimentary sequences containing distal LST, we carried out a multi-disciplinary field study at two sites, 500 km and 350 km from source. At Paddenluch outcrop, where distal LST is exposed in an infilled glacial meltwater-channel, we used combined high-resolution sedimentological, tephrochronological, geochemical and palynological methods to test strategies for effective sampling, characterise the main marker horizon, identify potential secondary LST beds, and classify post-depositional processes on a macro- and micro-scale. A core from the relatively undisturbed edge of the channel was subjected to the same analysis as targeted open-profile sediment columns from the channel centre, where slumping has deformed the sequence. At Krumpa geotope we focused on macroscopic observations to characterise a range of post-depositional periglacial processes that resulted in a very disturbed sedimentary sequence containing multiple LST beds.
Our results suggest that it is crucial for tephrochronological studies to collect multiple bore cores from any given site to evaluate potential disturbances and that micro-analytical methods prove useful tools to distinguish primary and post-emplacement processes in sedimentary sequences that rely on core data. No evidence of earlier LST beds were found, indicating that suggestions of precursor eruptions from Laacher See Volcano based on distal tephra occurrence are inadequate.

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C-14 data quality assessment: A key practice at the Rafter Radiocarbon Laboratory

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Poster Session 2, Mezzanine Floor, C-Block, November 24, 2020, 4:30 PM - 11:00 PM

During 1986–1990, the Rafter Radiocarbon Laboratory made the transition from beta-decay counting to Accelerator Mass Spectrometry (AMS). The vastly reduced sample size requirement, from typically grams to milligrams of carbon, was a boost for research interests to which the new radiocarbon technique could be applied. In the early years of AMS reported uncertainties were often on the order of 1%, equivalent to ca. 100 conventional radiocarbon years, and significantly larger than counting precision. As AMS technology advanced internationally and our own AMS system was improved, measurement uncertainties were substantially reduced. This allowed other, smaller uncertainties due to sample preparation to become apparent and quantifiable. At present, we assess all our analytical uncertainties regularly and combine them into one analytical uncertainty for each reported sample result.

Here, we report on the overall uncertainty for various sample types commonly prepared in our laboratory, focussing on results since 2010 when our most recent AMS system, XCAMS, was installed. Repeatability and accuracy are assessed and verified through analysis of secondary standards and blanks derived from internationally distributed reference materials as well as in-house standard materials. The lab's quality assessment results are evaluated across all our sample preparation methods, including atmospheric CO_2, water-dissolved inorganic carbon, carbonate (e.g. shell, coral) and organic (macrofossils, wood, charcoal, bone, etc.) samples. We consider both “large” samples > 0.3 mg carbon as well as those in the 0.1–0.3 mg C size range which tend to have larger uncertainties. We demonstrate that our laboratory consistently replicates the consensus values for the reference materials, even for small samples. Preparation error is smallest for air CO_2 samples and slightly larger for organic and inorganic samples, resulting in overall uncertainties of (0.13–0.3)%, depending on sample type and AMS measurement duration.

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