Geology Postgraduate Prospectus

2021

guide to graduate study

University Of Otago

Geology Postgraduate study

Take your degree to the next level

During your postgraduate degree you will work with world leading researchers and make a direct contribution to our understanding of Planet Earth.

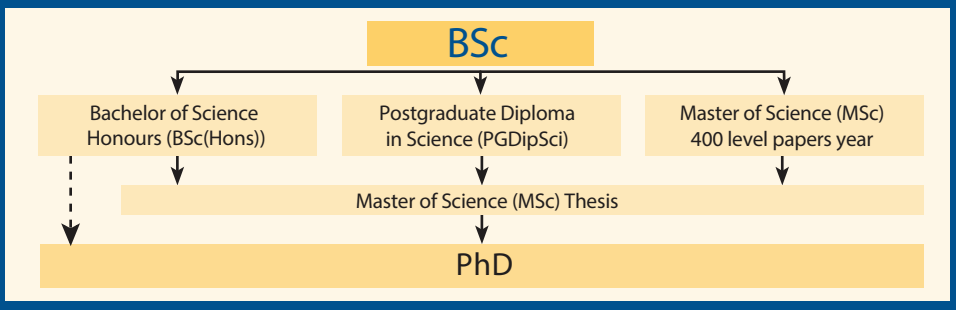
What can I study?

The Department of Geology has world leading researchers and offers a wide variety of projects ranging from earth hazards (volcanoes and earthquakes), deep earth processes, rock and ice physics, palaeoclimate and palaeoceanography, evolution of earth's biota (palaeontology and palaeobotany), economic geology (precious metal mineralisation), environmental geochemistry and remediation, and geophysics. Our research projects are truly global with field areas ranging from New Zealand, to Antarctica, Europe and North America.

During your degree you will become a member of our lively department and we will prepare you for further study at other institutions or to get an exciting job as an earth scientist.

Which is the right degree for me?

Just one additional year of study will earn you a valuable postgraduate degree. You may be looking to add just a little bit more knowledge on your undergraduate degree (BSc Hons/PGDipSci) or perhaps you want the freedom of a full year of research only time during an MSc.



Where will my degree take me?

Our graduates can be found all over the world including in New Zealand, Australia, South and North America, Europe, Asia and Africa. Otago geologists have pursued further study overseas (PhDs and PostDocs), have become researchers and lecturers, or are employed as economic geologists (exploration or extraction), geophysicists, by regional councils, port authorities and at mine sites for environmental monitoring, and as science educators.

Great... where do I learn more?

Come and visit us in the Geology Department behind the clock tower or visit www.otago.ac.nz/geology/study/index.html

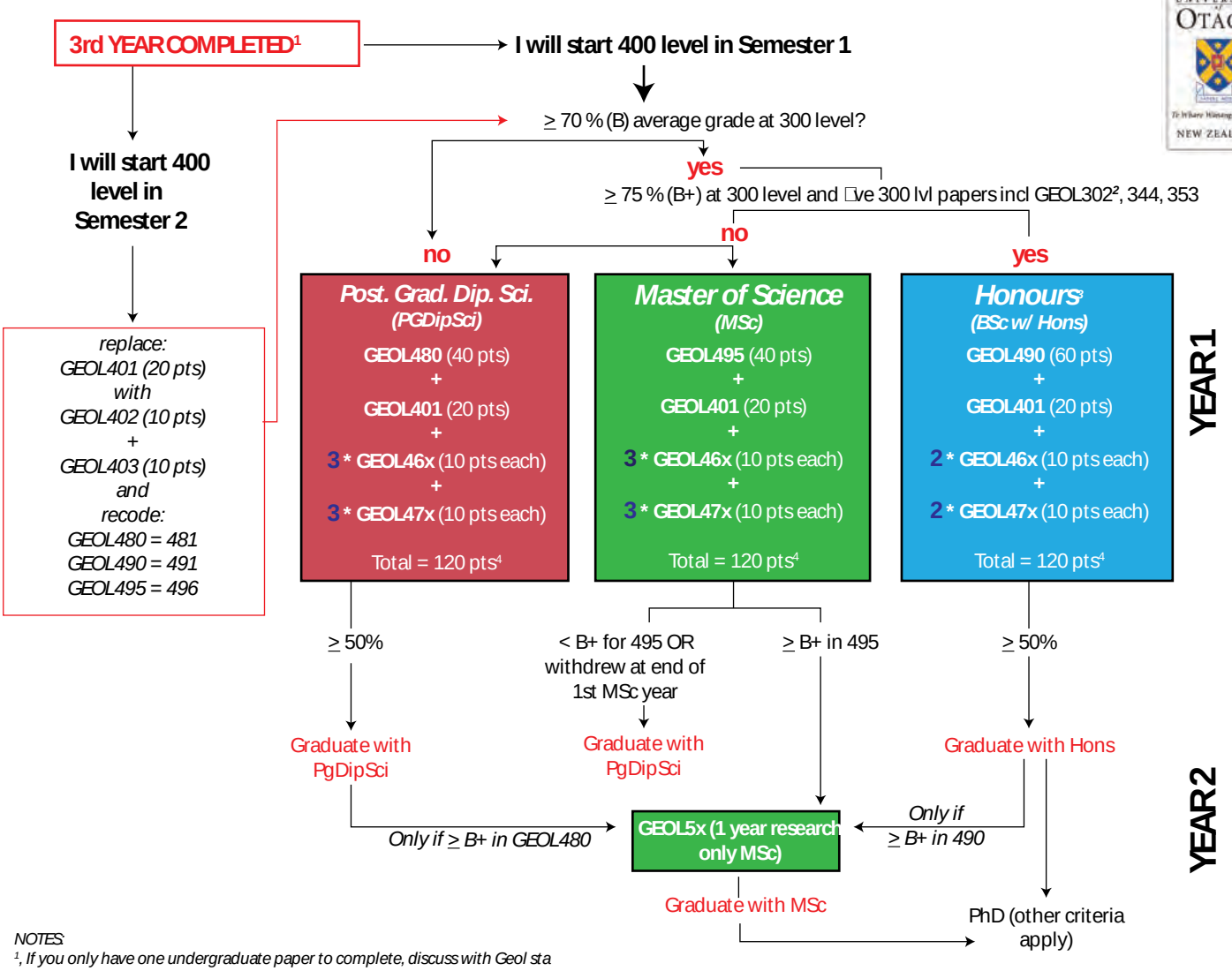
Degrees

	PGDipSci	MSc	BScHons	MAppSc
entry requirement	BSc	BSc with ≥ B ave in 300-level	BSc with ≥ B+ ave in 300-level & GEOL 302/321	BSc or equivalent work experience
research paper	GEOL480	GEOL495	GEOL490	APPS597
pts	40*		60	40
GEOL401 or equivalent (pts)	20			
additional 400-level papers (pts)**	60		40	120
total pts	120			180***
where does it lead?	if ≥B+ in research paper, then entry to 1 yr research MSc		if ≥B+ in GEOL 490, then entry to 1 yr research MSc or PhD	
	if <B+ in research paper, then PGDipSci			

* option of 60 pt research project & 4 x 10 pt papers
** 1 outside GEOL per semester
*** 2 or 3 semesters

Entry into GEOL400 level pathways

Department of Geology, University of Otago



NOTES:

[1], If you only have one undergraduate paper to complete, discuss with Geol sta

[2], GEOL302 or equivalent usually required; for example, GEOG 380 is appropriate too.

[3], Student Allowance ONLY availbable for Hons (as StudyLink considers Hons to be undergrad but not MSc and PGDipSci)

[4], 1 of 46x or 47x papers per semester can be replaced with an external paper of equivalent value. Note: 46x in Semester 1, 47x in Semester 2. See Geology website for more details

Last modified Sept 2019

GEOL 400 LEVEL PAPERS

See Geology Website for more details about papers.

Project papers:

GEOL480/481 *Research Project* (PGDipSci) GEOL490/491 *Dissertation* (Hons) GEOL495/496 *Master's Thesis Preparation*

Core papers:

GEOL401 *Current Topics and Advanced Methods in Geoscience* (Full year)
OR
GEOL402 *Current Topics and Advanced Methods in Geoscience 1* (Semester 2) **AND**
GEOL403 *Current Topics and Advanced Methods in Geoscience 2* (Semester 1 in following year)

Optional papers:

Semester 1:
GEOL461 *Advanced Topics in Geophysics 1*
GEOL462 *Advanced Topics in Geochemistry*
GEOL463 *Advanced Topics in Paleobiology and Evolution*
GEOL464 *Advanced Topics in Igneous Processes*
GEOL465 *Advanced Topics Structural Geology*

Semester 2
GEOL471 *Advanced Topics in Geophysics 2*
GEOL472 *Advanced Topics in Environmental Geochemistry*
GEOL473 *Advanced Topics in Paleoceanography and Paleoclimat.*
GEOL474 *Advanced Topics in Metamorphism and Mineralisation*
GEOL475 *Advanced Topics in Rock Deformation*

Papers

Required papers

GEOL401 Current Topics and Advanced Methods in Geoscience – 20 Points
Contemporary views and important recent advances in geoscience research. Advanced methods and techniques in field- and laboratory-based geoscience research including research planning, scientific writing and presentation of findings. The paper helps students to understand the process of preparing and planning research, and writing research proposals. It also increases the breadth of understanding of current ideas and methods in geosciences.

Training in planning and proposal writing in the first three weeks. A field seminar is scheduled in the first semester. Attendance at department seminars is expected across the year, with a portfolio of notes submitted at the end of the first and second semesters. A research talk based on student research projects occurs in the second semester. May be taken as GEOL402 (10 pts, S2) & GEOL403 (10pts, S1).

AND

GEOL490 – BSc Honours dissertation – 60 Points
A specific aim of the Bachelor of Science with Honours (BScHons) project is to develop advanced theoretical and research skills and in so doing to provide a platform for an advanced professional or academic career. It provides entry to the PhD programme, pending marks.

OR

GEOL480 – Postgraduate Diploma in Science Research project – 40 Points
The PGDipSci is a one-year programme that builds on an undergraduate science degree. The diploma encompasses both papers and a research topic, and can be taken full- or part-time. It provides entry to the Master of Science (MSc) degree by thesis only.

OR

GEOL495 – Master of Science Thesis preparation document – 40 Points
The MSc is a two-year degree that encompasses both coursework and research. The first year involves mainly coursework and preliminary research preparation. Students will have the opportunity to contribute to existing fields of research, or to begin to develop new areas. The PhD programme can be entered upon completion, pending marks.

OR

APPS597 – Supervised Independent Study – 40 Points
A supervised independent study resulting in a piece of original work on a specific research question or an advanced critical analysis of existing, area-specific, literature and knowledge.

Optional papers (60-80 Points out of the way, 60-120 Points to go)

			Coordinator(s)
S1	GEOL461	Advanced topics in Geophysics 1	ARG
S1	GEOL462	Advanced topics in Geochemistry	CEM
S1	GEOL463	Advanced topics in Paleobiology and evolution	REF
S1	GEOL464	Advanced topics in Igneous Processes	JDLW / MB
S1	GEOL465	Advanced topics in Structural Geology	SAFS
S2	GEOL471	Advanced topics in Geophysics 2	CO
S2	GEOL472	Advanced topics in Environmental Geochemistry (CRL)	JMS
S2	GEOL473	Advanced topics in Paleoceanography and paleoclimatology	CMM
S2	GEOL474	Advanced topics in Metamorphism and mineralization	JMS
S2	GEOL475	Advanced topics in Rock Deformation	MWS

The optional 400 level papers are different to undergraduate lectures. The classes are about critical thinking and analysis – these are skills that are highly valued in the workplace regardless of where you end up.

Each paper is worth 10 points . The university expects that 1 point = 12 hours of work . This includes meetings, fieldtrips, tutorials, readings and exam preparation. Most papers require 2-3 hours of reading (and note-taking) of assigned journal articles before each class.

There are no prerequisites for any of these papers. You may never have taken xxxx as an undergrad, but now you can become an expert in it.
Your Bachelor's degree really is worth something – you've learned how to learn!

Semester 1:

GEOL461: Advanced Topics in Geophysics 1

Andrew Gorman

Practical and conceptual approaches to applying geophysical methods (particularly seismology) to investigate and image geological features and the processes that have formed such features.

GEOL462: Advanced Topics in Geochemistry

Candace Martin and Mike Palin

Principles and applications of geochemistry to studies of rocks, ores, sediments, soils and natural waters. Topics vary, in 2020 we explored the geochemistry of carbonates:

- Carbonate minerals
- Aqueous carbonate equilibria
- Marine carbonates-stable isotopes
- Marine carbonates-paleo records
- Acid rock drainage-carbonate remediation
- Hydrothermal carbonates-reactions
- Hydrothermal carbonates-isotopes
- Metamorphic carbonates
- Magmatic carbonates
- Mantle carbonates
- Carbonate mineral sequestration

GEOL463: Advanced Topics in Paleobiology and Evolution*
Ewan Fordyce
Fossils and the origins of the New Zealand biota; macroevolution, past and present; case studies in paleobiology. (*May not be offered in 2021.)

GEOL464: Advanced Topics in Igneous Processes
Marco Brenna and James White
Practical and theoretical investigations of igneous rock suites, with the goal of understanding the processes that lead to magmatism on Earth.

GEOL465: Advanced Topics in Structural Geology 1
Steven Smith and Dave Prior
This paper explores what happens during earthquakes; how faults and fault systems grow; how faults control mineralization in the crust; how shear zones deform in rocks and ice. Students are given the opportunity to research a topic of their own choice, and taught sessions will focus on interactive discussion of key processes and state-of-the-art research. Taken together with GEOL475, these two papers provide a comprehensive background in structural geology, active tectonics, earthquakes, hazard, and risk.

Semester 2:
GEOL471: Advanced Topics in Geophysics 2
Christian Ohneiser
Practical and conceptual approaches on the use of rock- and paleo-magnetism in stratigraphic, chronostratigraphic, environmental, volcanic, structural and tectonic studies.

GEOL472: Advanced Topics in Environmental Geochemistry
James Scott
A theoretical and practical paper focused on geochemical contamination and remediation processes. Involves a 2-week short course (70%) and a practical application of environmental methods (30%).

GEOL473: Advanced Topics in Paleoceanography and Paleoclimatology
Chris Moy and Christina Riesselman
Advanced discussion and analysis of marine and terrestrial records used to reconstruct oceanographic and climatic change.

GEOL474: Advanced Topics in Metamorphism and Mineralisation
James Scott
A theoretical and practical investigation of metamorphic rocks, processes, and mineralisation.

GEOL475: Advanced Topics in Rock Deformation
Mark Stirling

- Earthquake physics and statistics
- Tectonic geomorphology and paleoseismology
- Integration of instrumental and geological earthquake data
- Earthquake hazard analysis
- Time-dependency of earthquakes
- Outputs for end-users
- Multi-hazards

- Alpine Fault case study
- Hikurangi subduction zone case study

Research Projects

Title: Volcanism in Central Otago

Supervisor: Marco Brenna + James White + Christian Ohneiser

Level: BSc or MSc

Description: Miocene volcanism in the Otago region formed the large Dunedin Volcano as well as numerous dispersed small eruptive centres that together make a volcanic field. Similar volcanism is widespread around the world and can pose a threat to densely populated centres (e.g. Auckland). Clues to understanding the origins of dispersed volcanic fields are often concealed in the smaller volcanoes, whose magmas experienced lesser differentiation processes. Given the large number and complexity of the small dispersed volcanoes around Central Otago several projects can be designed, ranging from reconstructing eruptive history through field studies, examining chemical and petrographic character of eruptive deposits or estimating ages through palaeomagnetism.

Recommended background: GEOL X61, GEOL X62 and GEOL X64

Tuff and spatter exposed in the Macraes mine (photo credit: James White)

Title: The structural and lithological characterization of the Port Chalmers Breccia

Supervisor: Marco Brenna + James White + Christian Ohneiser

Level: BSc or MSc

Description: The Port Chalmers Breccia exposed around Port Chalmers in the Dunedin Harbour has historically been interpreted as a massive vent filling deposit. This project aims to better characterize structures and grading of the overall deposits in the Port Chalmers area. The project will involve a significant component of detailed fieldwork to map geological relationships, measure structural and stratigraphic data, describe lithologies and collect samples, for detailed petrological and palaeomagnetic characterization of the Port Chalmers Breccia and the rocks surrounding it. The goal is to produce a revised and improved map of the Port Chalmers Breccia outcrops and to interpret its mode of emplacement.

Recommended background: GEOL X61 and GEOL X64

Port Otago from the Lady Thorn rhododendron dell, an early quarry of Port Chalmers Breccia rock.

Basin Evolution of Paterson Inlet, Stewart Island

PGDipSci, Hons, MSc

Supervisor: Andrew Gorman and/or Christina Riesselman and/or Chris Moy

Description: For several years, OCN323 has been running an annual field school to Stewart Island. During that time, we have developed a large dataset of seismic boomer data – complemented by CHIRP, multibeam, sediment samples and cores. The data are calling out to be integrated and analysed as a coherent package. Projects could involve a wide range of topics including: structural controls on the Paterson Inlet basin, glacial period environmental systems and erosional processes in the basin, Holocene infill history, biogenic gas systems within the inlet.

Recommended preparation: GEOL261 or 361, OCEN323, GEOL262 or 362

"Marine" seismic imaging of the Ostler Fault in Mackenzie Country, central South Island, New Zealand

PGDipSci, Hons, MSc

Supervisor: Andrew Gorman

Description: The aim of this project is to collect, process and analyse seismic boomer data in the Pukaki and Ohau canals (between Lakes Pukaki and Ohau and Lake Ruataniwha) and within Lake Ruataniwha (near Twizel) to image the active Ostler Fault and better assess its earthquake hazard. Seismic processing of data like this has been proven feasible recently in Otago Harbour.

Recommended preparation: GEOL261 or 361, OCEN323

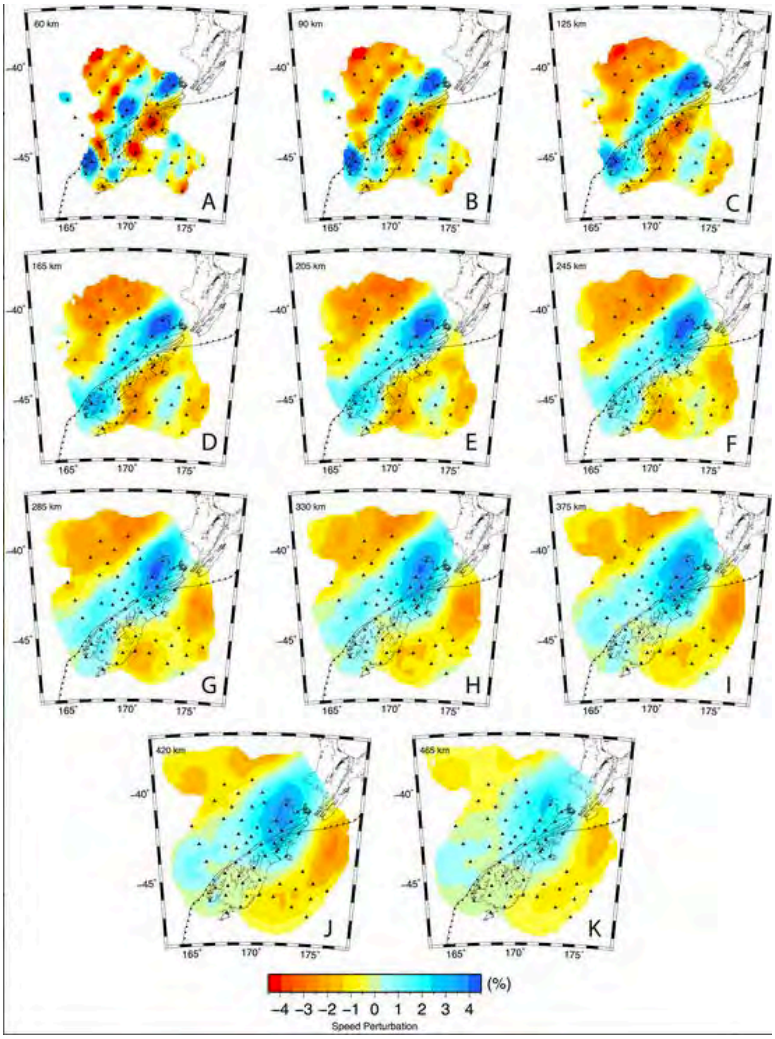
Developing a crustal P-wave velocity model for SE South Island using petroleum industry sources and land-based broadband seismometers

PGDipSci, Hons, MSc

Supervisor: Andrew Gorman and Danna Eberhart-Philips (GNS)

Description: This project will use travel time determinations between air gun sources at sea and stationary earthquake seismometers on land to produce a 3D model of velocity structure in the crust (and possibly the upper mantle). An extensive dataset of seismic records exists already; this project would primarily involve analysing that dataset to investigate the dynamic crustal processes that led to the assemblage of South Island terranes.

Recommended preparation: GEOL261 or 361, GEOL353



(image from Zietlow DW, Molnar PH, Sheehan AF. JGR: Solid Earth. 121(6):4427-4445)

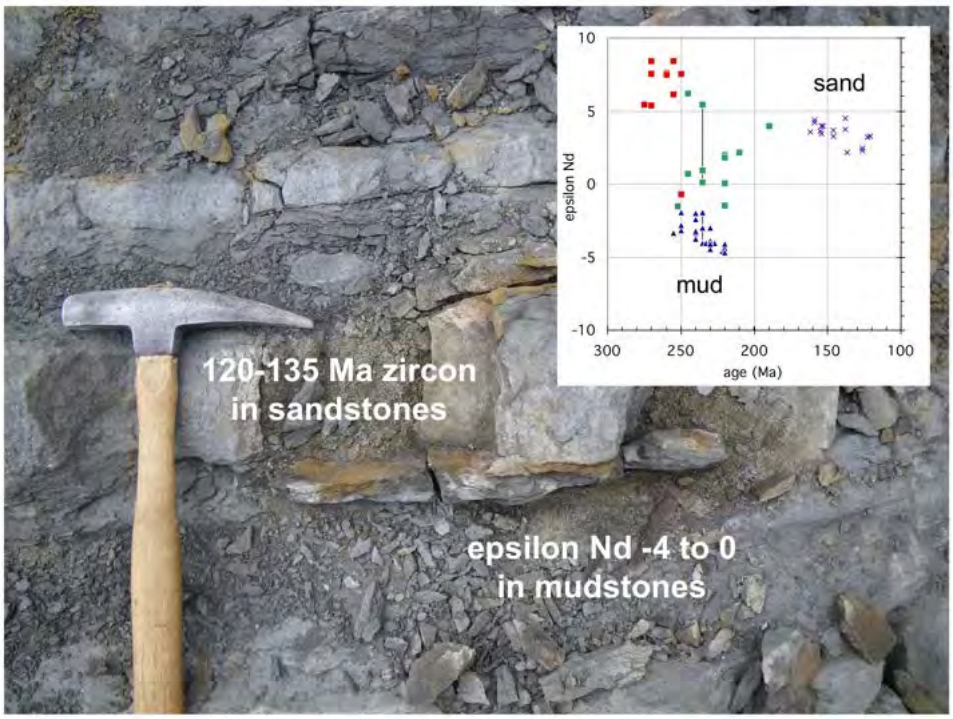
Provenance of sand and mud in turbidites using detrital zircons and neodymium isotopes

MSc

Supervisors: Candace Martin and Mike Palin

Description: Turbidites are widespread sedimentary deposits of economic and scientific importance. They dominate Mesozoic sedimentary rocks of the Eastern Province and younger Cenozoic basins. This project will address a basic question: where does the sand and mud in a turbidite come from? Early results indicate very different sources. The work will involve field documentation of samples, petrography, XRD and Nd isotope analysis of mudrocks, and U-Pb dating of detrital zircons in sandstones by LA-ICP-MS.

Recommended preparation: GEOL 262/362, 263/363 and 273/373 or equivalent.



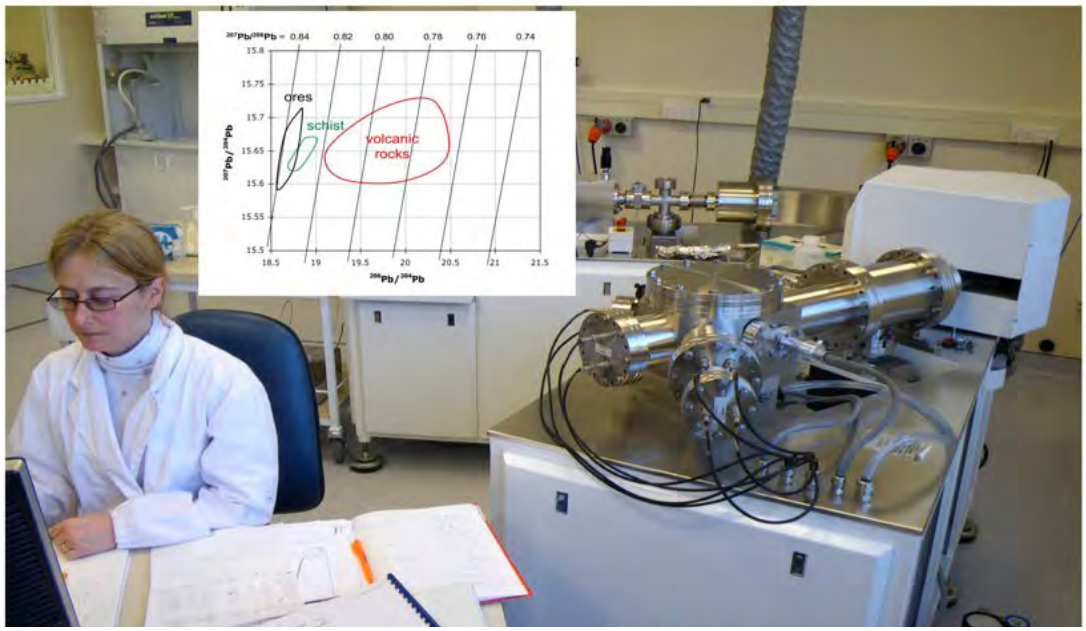
Tracing gold mineralization and associated heavy-metal pollution using lead isotopes

MSc

Supervisor: Candace Martin and Claudine Stirliing (Otago Centre for Trace Element Analysis)

Description: Mortensen et al. (2010) have reported lead isotope data for several gold deposits in Otago. The data indicate lead was extracted from the host schist at 150-100 Ma. The few lead isotope data that are available for the host rock schist are more radiogenic due to subsequent uranium decay. Younger basalts contain even more radiogenic lead from their mantle source. This means lead from the gold ores and surrounding rocks should be able to be distinguished on the basis of its isotopic composition. This project will involve sampling and Pb isotope and trace element analysis of schist, sedimentary rocks and soils around old mines and control sites to test whether lead isotopes provide a useful fingerprint for gold mineralization and heavy-metal pollution.

Recommended preparation: GEOL 262/362 or equivalent.



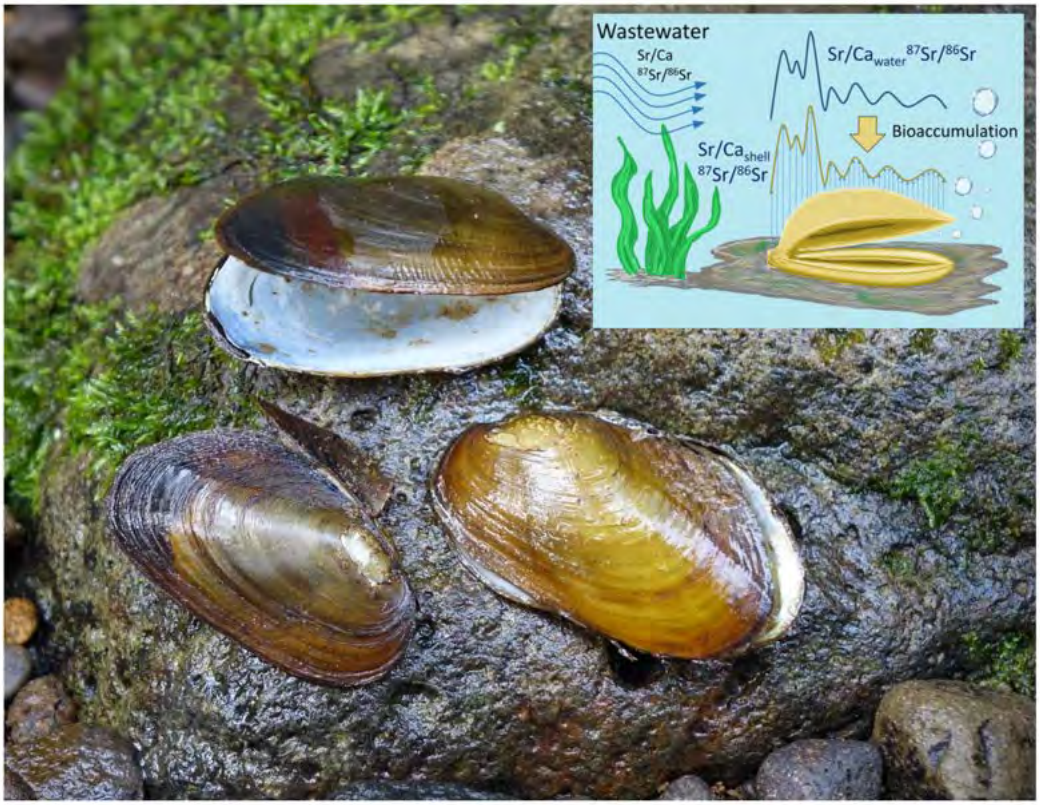
Trace elements in freshwater bivalve shells as records of water quality

BScHons or MSc

Supervisor: Candace Martin

Description: A key uncertainty in water quality assessment is establishing a natural baseline. The carbonate shells of freshwater bivalves should reflect the composition of the water from which they precipitate. High spatial resolution analysis of trace elements in fossil shells could therefore provide a time series record of past water compositions and hence a natural baseline. This project will analyze trace elements in water and shells from living mussels (kakahi, *E. menziesii*) from a variety of locations to test this proposition. If reproducible data can be obtained from modern examples, then fossil shells will be examined as well.

Recommended preparation: GEOL 262/362 and 272/372 or equivalent.



Drought in the land of the long white cloud: Exploring New Zealand's hydroclimate past towards a sustainable future

BScHons or MSc (preferred)

Supervisors: Chris Moy, Marcus Vandergoes (GNS Science), Andrew Gorman and Christina Riesselman

Description: In New Zealand we lack a comprehensive understanding of the drivers, magnitude, and frequency of pre-instrumental drought, however this is essential information needed by decision makers to develop adaptation and mitigation strategies for future climate change. This project will develop a record of hydrological change that will reconstruct drought events using lake sediment cores to act as natural "rain gauges" from the South Island. We will use geophysical imaging techniques combined with radiocarbon-dated sediment cores to determine the timing and magnitude of former lake lowstands driven by negative hydrologic balance. These data sets will be integrated with continuous geochemical records of lake water evaporation to reconstruct periods of hydrologic deficit and produce NZ's first quantitative lake level curve. This research project will provide essential information that will contribute to management decisions for regional councils, iwi and environmental stakeholders.

This project is ideal for students with an interest in climate science, sedimentology, geophysics and/or geochemistry. The project will involve both field and laboratory work.

Reconstructing temperature change during the last millennium from New Zealand lake sediments

MSc

Supervisors: Chris Moy, Marcus Vandergoes (GNS Science), Sebastian Naeher (GNS Science) and Catherine Beltran

Description: High resolution paleoclimate records spanning the last 1,000 years are critical for establishing hydroclimate baselines, determining the magnitude of past temperature change and evaluating potential climate drivers. Yet, there are very few highly resolved and well dated records from New Zealand that can provide this perspective. A primary goal of the Lakes380 programme (lakes380.com) is to evaluate how climate and landscape change impact water quality in 10% of New Zealand's lakes (n=380) since first human arrival approximately 700 years ago.

This MSc project will compile multiple organic geochemical records of climate change from New Zealand to help establish a baseline of climate and environmental change. We are seeking an enthusiastic MSc student to join our international research team to participate in the collection and analysis of sediment cores obtained from multiple NZ lakes. The student will utilize sediment samples collected from a diversity of lakes across climate gradients to evaluate the abundance and applicability of temperature-sensitive organic biomarkers. The results of this calibration study will then be applied to downcore sediment records in order to reconstruct temperature change over the last millennium.

This project is ideal for students with an interest in climate science, sedimentology and geochemistry. The project will involve field and laboratory work.

Reconstructing millennial-scale coupled atmosphere-ice sheet dynamics in the SE Pacific during the Pleistocene

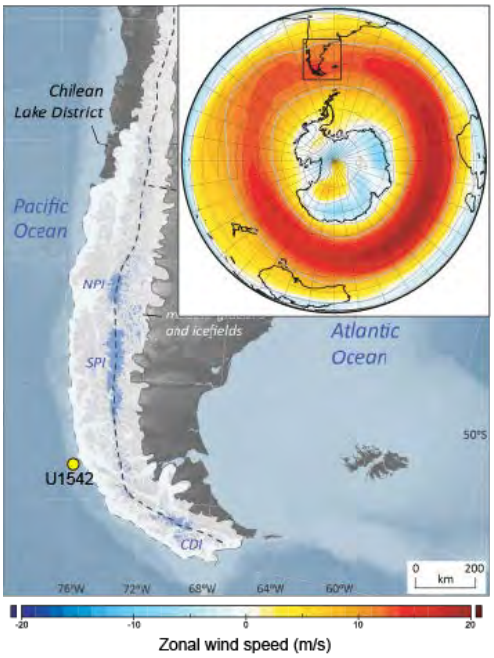
Supervisors: Chris Moy, Christina Riesselman and Catherine Beltran

MSc

Description: The northern and southern Patagonian ice sheets are the most prominent glacial features in southern South America, and when combined, they represent the largest and most extensive areas of ice in the Southern Hemisphere outside Antarctica. The extent of Patagonian glaciers is a sensitive climate proxy that responds to temperature and precipitation. In 2019, IODP Exp. 383 recovered a Pleistocene sedimentary sequence from the upper continental slope along the southernmost Chilean margin that is well positioned to reconstruct the history of Patagonian glaciation.

This project will reconstruct changes in Patagonian ice sheet extent over the last ~700 kyr, using a highly resolved composite sediment stratigraphy obtained from Site U1542. μ-XRF elemental abundance, bulk organic C + N stable isotopes and concentrations, and n-alkane/GDGT distributions will be used to evaluate millennial-scale changes in organic matter and sediment provenance related to ice proximity. The resulting record will be compared to regional, Southern Ocean and Antarctic paleoclimate records to: 1) evaluate key oceanic-atmospheric mechanisms driving changes in ice extent during the Pleistocene; 2) determine the sensitivity of the Patagonian ice sheet to elevated temperatures during warm interglacials and Antarctic warming events ; 3) constrain sediment transport mechanisms; and 4) evaluate land-sea influences on phytoplankton productivity.

This project is ideal for a student with an interest in climate science, sedimentology, geochemistry and data science. The project will involve processing large data sets (data mining) and a laboratory component measuring existing samples.



Eocene – Oligocene New Zealand paleoclimate reconstruction

Dr Christian Ohneiser, Dr Chris Moy, Dr Catherine Beltran, Dr Christina Riesselman

We have a collection of four drill cores (Mako- 1-4) which contain a terrestrial to marginal marine successions spanning the Eocene - Oligocene boundary. The E-O boundary saw a significant shift in the global climate system with the growth of the first significant ice sheet in Antarctic and a reduction in atmospheric CO2. How New Zealand faired in during this transition is poorly understood. This project (ideally suited for an MSc) involves developing an orbital scale (Milankovitch) magnetostratigraphic age model, a core log, and organic geochemical (biomarker) studies to reconstruct the ancient climate (temperature) setting and potentially vegetation evolution.

Paleoclimate reconstruction of Mars

Dr Christian Ohneiser Associate Professor James Scott

High resolution satellite imagery of Mars have revealed cyclic sedimentary deposits. The sedimentary deposits, which are thought to be >2Gyr old, and indicate active sedimentary system/cycle and that the climate system may have bene forced by Milankovitch orbital cycles. This project involves using the latest time series analysis techniques in combination with high resolution satellite imagery to understand better the frequency content of these sedimentary packages and the evolution of the successions in relation to Milankovitch forcing. Field work is not planned.

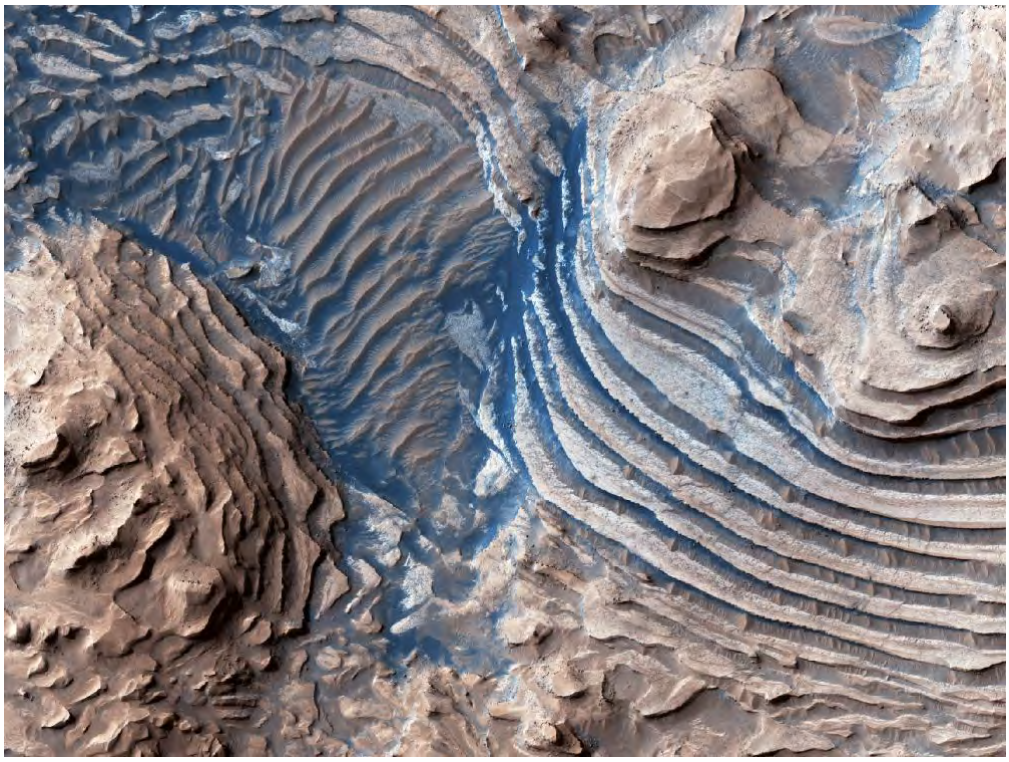


Figure 1 Satellite image of Martian sediment beds (www.universetoday.com)

Environmental magnetic (paleocurrent) and biomarker reconstitution of Oligocene – Miocene boundary in the Waiau Basin, Southland.

Dr Christian Ohneiser, Dr Catherine Beltran, Dr Christina Riesselman

The Oligocene – Miocene boundary hosted a transient expansion of the Antarctic ice sheet known as the Mi-1 event (Wilson et al., 2008). This event is recognised in successions around the world but high resolution reconstructions are spars in New Zealand. The Foulden Maar successions provided the first annually laminated record which indicated that New Zealand was influenced by both polar and tropical weather systems. A concomitant high resolution record from the marine realm is lacking. This project will fill this gap and will involve a paleotemperature and paleocurrent reconstruction on rhythmically bedded Oligocene – Miocene sediments from the Waiau Basin, western Southland, New Zealand.

Magma Recharge and Eruption during Formation of the Greenhills Mafic Intrusion

BScHons or PGDipSci

Supervisor: Mike Palin

Description: The Greenhills Complex is a small layered mafic intrusion exposed on the Bluff Peninsula. The cumulate sequence is dunite-clinopyroxene-gabbro and contains the only *in situ* occurrence of platinum-group minerals in New Zealand. Previous mapping, petrography, and mineral compositions indicate that the complex was produced by fractional crystallization of hydrous basalt. The question of how much magma recharge and/or eruption occurred during its formation can be addressed by tracking changes in magma composition and temperature using cumulate minerals. This project will involve fieldwork to collect new samples, preparation and petrographic examination of new and archived samples, and *in situ* analysis of major and trace elements in cumulate minerals by SEM-EDS and LA-ICP-MS.

Recommended preparation: GEOL x62 and x64

Enigmatic Enclaves – Exceptional Examples of Endogenous Evolution or Exogenous Entities?

BScHons

Supervisor: Mike Palin

Description: Dioritic intrusions along the South Coast contain microgranular (aka mafic) enclaves. These are spectacularly exposed at Kawakaputa Point, west of Riverton. The goal of this project is to determine whether the enclaves represent disrupted plutonic chilled margins, mingled mafic magma, or unrelated xenoliths. The work will involve field documentation of samples, petrography, textural and mineral analysis by SEM, and trace element, Sr isotope analysis and zircon U-Pb dating by LA-ICP-MS.

Recommended preparation: GEOL x62 and x64

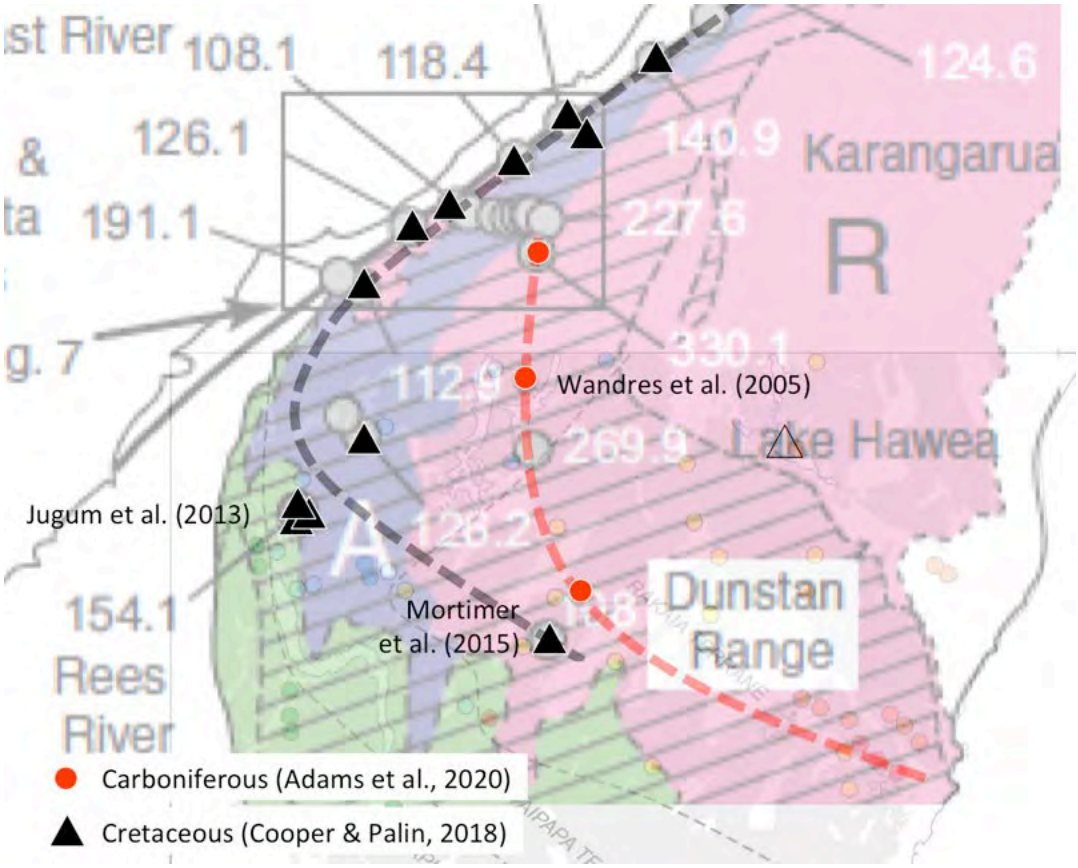
Is a Cryptic Late Cretaceous Suture Hidden in the Otago Schist?

BScHons or MSc

Supervisor: Mike Palin

Description: Detrital zircon evidence from the Alpine Schist (Cooper et al., 2013; 2015; Cooper and Palin, 2018) indicates accretion of the Late Cretaceous Pounamu Terrane from the west. The metamorphic core of the Otago Schist has recently yielded detrital zircons as young as 108 Ma (Mortimer et al., 2015) whereas overlying sedimentary sequences contain 112 Ma volcanics (Tulloch et al. 2009). Together, these findings challenge the prevailing paradigm for building Zealandia solely by terrane accretion from the east. The goal of this project will be to extend the detrital zircon database into central and eastern Otago. The work will involve field mapping and sampling, petrography, textural and mineral analysis by SEM, and zircon U-Pb dating by LA-ICP-MS.

Recommended preparation: GEOL x62 and x74



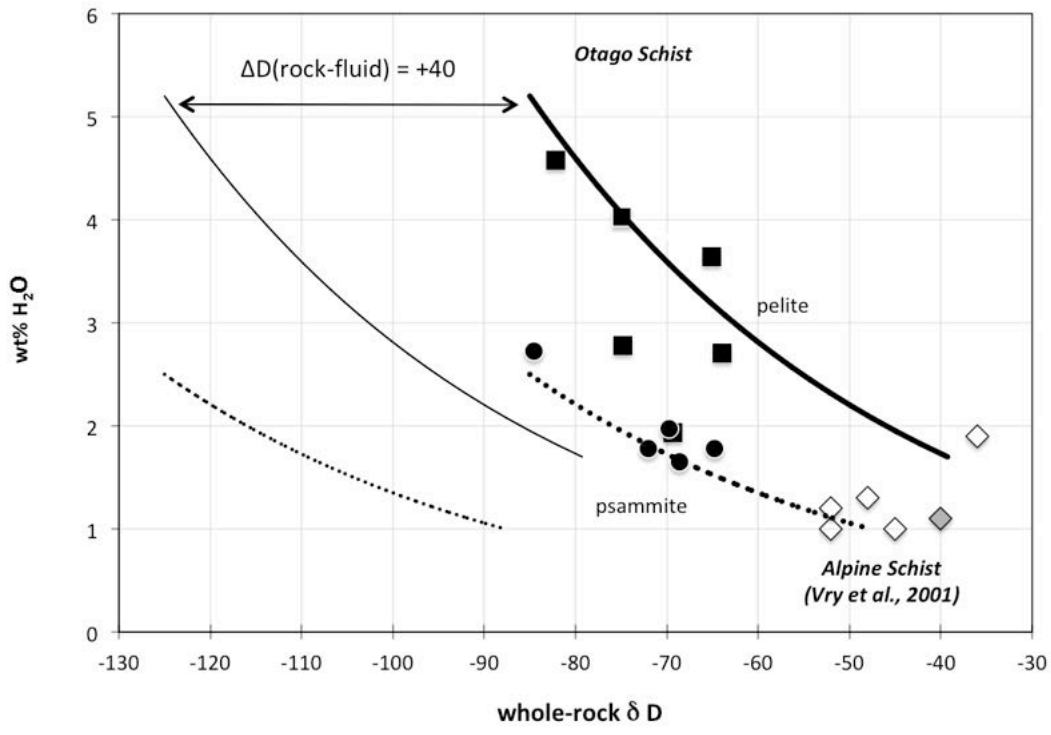
Metamorphic Methane and Gold Mineralization in the Otago Schist

MSc

Co-supervisors: Mike Palin & Greg Holk (California State University, Long Beach)

Description: Metamorphism of sedimentary rocks involves the release of water-rich, carbon- and sulfur-bearing fluids. Such fluids play essential roles in the long-term carbon cycle, deformation of the crust, and formation of gold deposits. This project will examine the stable isotopes of hydrogen and carbon – the two most abundant volatile elements in metamorphic fluids – in the Otago Schist across metamorphic grade. Preliminary results confirm that systematic hydrogen isotope shifts are observed with increasing extent of volatile loss and metamorphic grade. These findings suggest release of methane rather than water at low grades. They also predict carbon and hydrogen isotope alteration halos around pathways of metamorphic fluid escape from higher grades – possibly including structures that host gold mineralization.

Recommended preparation: GEOL x62 and x74



Ice mechanics and the dynamics of ice sheets.

Hons, MSc, PhD

Supervisor: Dave Prior.

A variety of projects that can include various mixtures of the following activities.

- Laboratory ice deformation experiments in Otago, the University of Pennsylvania (Philadelphia) and the University of Tasmania (Hobart).
- Microstructural analysis of natural and laboratory ices using Cryo- electron backscattered diffraction.
- Acoustic properties of ice.
- Structural geology of glaciers
- Ice seismology to understand glacier and ice sheet dynamics.
- Modelling ice dynamics.

Specific projects often depend on availability of samples and data and you should talk to Dave to find out what might be possible in any particular year. There are possibilities for glacier fieldwork.

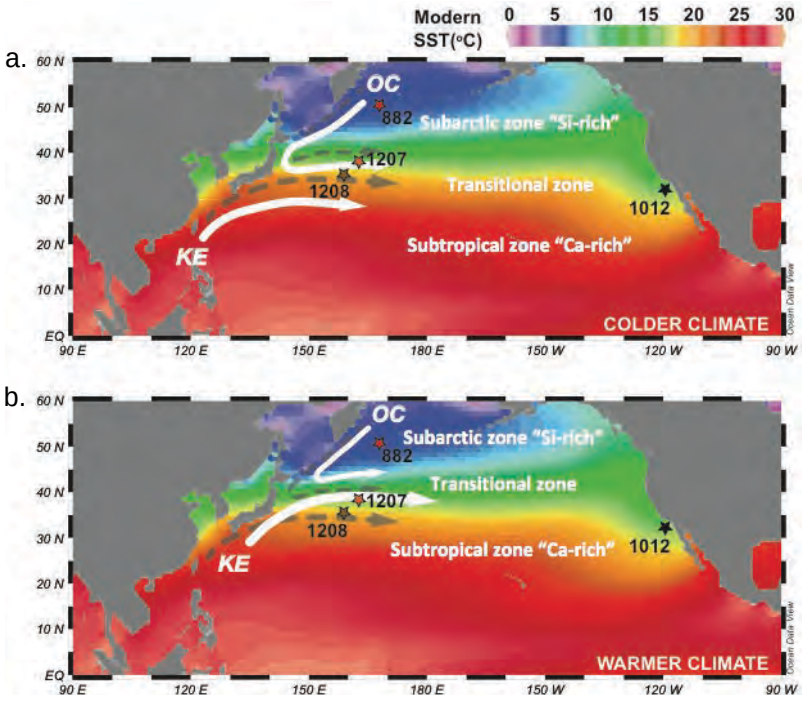
Northwest Pacific Ocean circulation across the Plio-Pleistocene climate transition

PGDipSci or BSc(Hons)
Supervisor: Christina Riesselman
International collaborator: Molly Patterson (Binghamton Univ., USA)

Description: “Super interglacials” are currently receiving increased research attention as they represent some of the most recent periods in Earth’s history when climate was warmer than today and yet the cause(s) of such extreme warmth remain unknown. However, there is a general lack of quantitative N. Pacific Ocean Plio-Pleistocene records, making it difficult to decipher the exact relationship between thermohaline changing circulation and other aspects of the global climate system during these “super interglacials”, as well as during major climate transitions in Earth’s history such as the inception of Northern Hemisphere glaciation (INHG) and mid-Pleistocene transition (MPT).

This project will track the position of major ocean currents by developing a high-resolution record of biogenic opal flux at ODP Site 1207 in the Northwest Pacific Ocean from the warm Early Pliocene to present (0-5 Ma), increasing to orbital resolution (e.g. 3-kyr time step) across the INHG (3.5 to 2.4 Ma) and the MPT (1400 to 400 ka). The resulting record will improve our ability to evaluate oceanic and atmospheric climatic dynamics of the N. Pacific through major climate transitions and during “super interglacials” like marine isotope stage (MIS) 31. Notably, in the few existing records from the northwest Pacific subarctic and mid latitudes that span the last 3 Myr, surface ocean conditions (i.e., SST) appear out of phase across the INHG and MPT, highlighting a unique non-linearity not observed in other regions of the global ocean.

This project is ideal for a student who is keen to use geochemistry to understand how past episodes of rapid climate change impacted the Earth system, and also enjoys the challenge of careful and precise work in a wet chemistry lab.



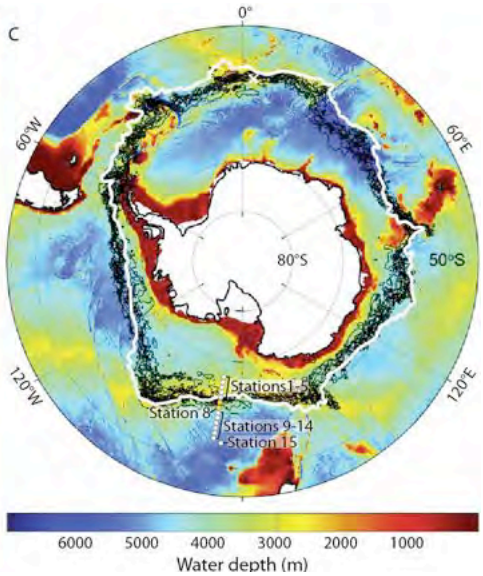
Priming the pump: Validating diatom sedimentary proxies to reconstruct Southern Ocean sea ice and biological pump efficiency

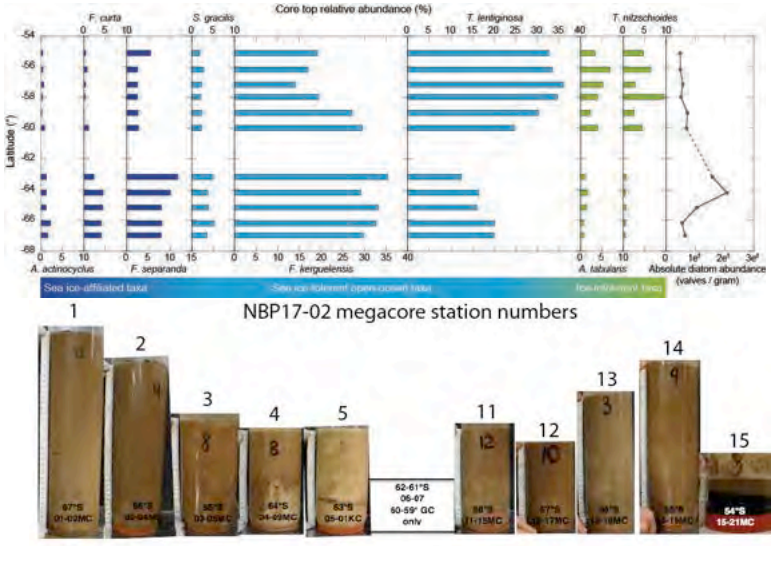
MSc (best fit) or BSc(Hons)
Supervisor: Christina Riesselman
International collaborators: Becky Robinson (Univ. Rhode Island) and Mark Brzezinski (Univ. California Santa Barbara)

Description: The seasonal sea ice zone of the Southern Ocean responds to and regulates global climate. Each winter, sea ice expands toward the southern boundary of the Antarctic Circumpolar Current, effectively doubling Antarctica's surface area (white line on the map below). Antarctic sea ice limits surface ocean-atmosphere gas exchange and acts as an insulator, trapping CO_2 and reducing heat flux. Its role as a barrier, coupled with the rejection of cold, salty brine as the surface ocean freezes, is thought to play an important role in both deep-water formation and the geometry of deep ocean water masses. As winter sea ice retreats rapidly in the spring, it seeds the water column with organisms, nutrients, and fresh water, stimulating large phytoplankton blooms that consume atmospheric CO_2 and support the Antarctic food webs of the polar ocean. Today, the Southern Ocean is responsible for 50% of the global ocean uptake of CO_2 produced by anthropogenic activities, a portion of which is exported through the activity of this biological pump and trapped in the deep ocean and sediments.

This project will use radiocarbon dating and the diatom assemblages in short cores collected along a 12° latitudinal transect across the polar frontal zone to reconstruct sea ice associated with the transition from glacial to interglacial climate. Assemblage data will be combined with shipboard measurements of water column properties, serving as a calibration data set to link surface ocean conditions to sedimentary assemblages in an understudied region of the Southern Ocean to fill an identified knowledge gap. If adopted as an MSc project, additional data sets will be developed from a long core collected at the modern polar front, which will be interpreted in the context of short core calibrations to examine the influence of frontal migration on the Southern Ocean biological pump.

This project is ideal for students who are interested in the carbon cycle, Southern Ocean sediments, and micropaleontology, and who are excited by the prospect of integrating their own data with other big data sets.

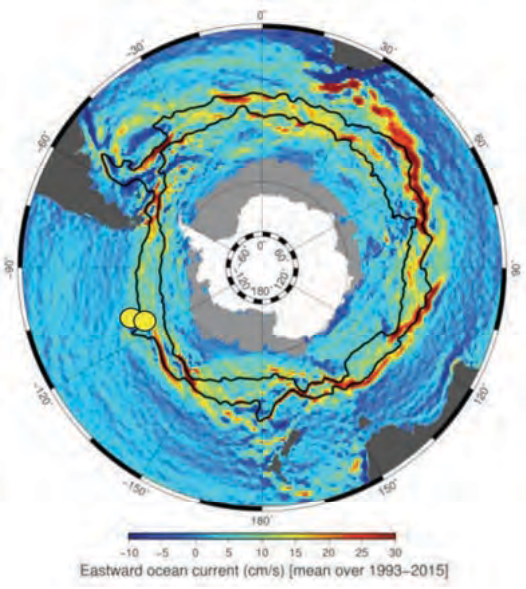




Calibrating the ice cores of the sea: What links East Antarctic temperature and Southern Ocean productivity?

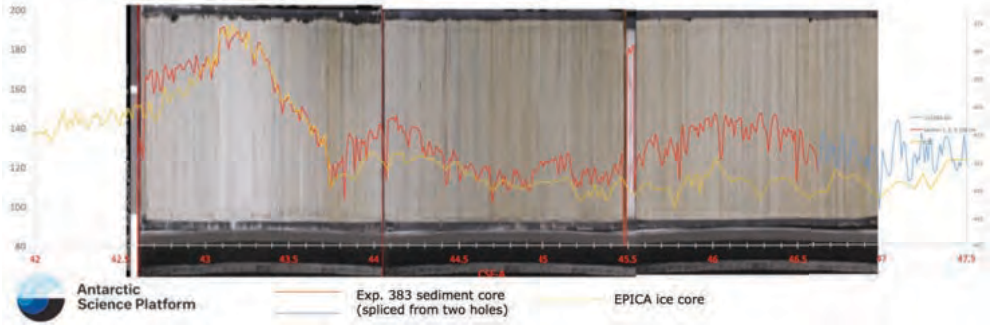
MSc (best fit) or BSc(Hons)
Supervisors: Christina Riesselman and Chris Moy
International collaborators: Christina Ravelo (Univ. California Santa Cruz), Gisela Winckler (Columbia University), and the IODP Exp. 383 Science Party.

Description: The Southern Ocean is responsible for 50% of the global ocean uptake of CO_2 produced by anthropogenic activities. The efficiency of the Southern Ocean carbon sink is partially driven by the biological pump, where phytoplankton blooms along the Antarctic Circumpolar Current consume CO_2, then settle to the seafloor, locking this carbon away in thick sedimentary sequences. Despite the importance of the biological pump in the global carbon cycle, the Southern Ocean is a challenging environment; very few cores have been collected from this important region and reconstructions of biological pump efficiency under warmer-than-present climates are rare.



In 2019, IODP Expedition 383 drilled two exceptional sites in the central South Pacific (map at right) that are ideal to fill this gap. Furthermore, shipboard data show a tight relationship between the physical properties of one of these cores, the ultra-high resolution Site U1539 where colour reflectance profiles closely co-vary with fluctuations in the isotopic signatures of Antarctic ice cores (example below). This project seeks to determine how these two records are linked, first by developing a continuous record of changes in diatom assemblage and biogenic silica across three Quaternary climate transitions. If adopted as an MSc project, this calibration work will also include analysis of carbon and nitrogen isotopes and concentrations, and the same proxy suite will be used to develop a reconstruction of the full 1.2 Myr record, linking the Southern Ocean carbon cycle to Antarctic continental conditions during key transitions in global climate.

This project is ideal for a student who's interested in climate, wants to develop and integrate micropaleontology and geochemistry data sets, and is also excited to join a dynamic community of IODP Exp. 383 and Antarctic Science Platform collaborators.

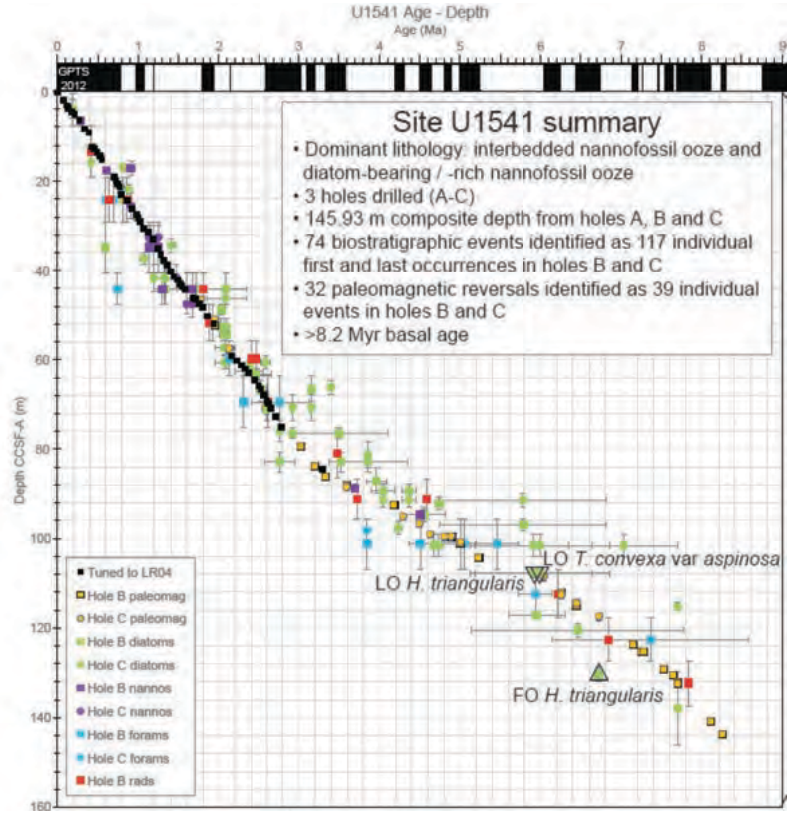


Developing a Neogene chronostratigraphic reference section for the Southern Ocean

MSc
Supervisors: Christina Riesselman, Christian Ohneiser and Rob McKay (VUW)
International collaborators: Joe Stoner (Oregon State Univ.), Christina Ravelo (Univ. California Santa Cruz), Jenny Middleton (Columbia University), and the IODP Exp. 383 Time Team

Description: The Southern Ocean is a prime driver of Earth's climate cycles, and understanding how this system responded to past intervals of rapid change will be essential to addressing society's future climate challenges. However, our ability to evaluate the timing of past change in the Southern Ocean is limited by a lack of chronostratigraphic reference sections where continuous sedimentation and excellent paleomagnetic signals allow biostratigraphic datums to be definitively calibrated.

This project will take advantage of three exceptional new sediment cores drilled by IODP Expedition 383 in 2019 in the central and eastern South Pacific ocean to develop the first chronostratigraphic referene section for the Southern Ocean. All three cores are continuous with no evidence of hiatuses. Basal ages range from 4.2 to 8.2 Ma. Each has an excellent shipboard magnetostratigraphy, and the upper portion is additionally tuned to the global benthic $\delta^{18}O$ stack. The project will primarily focus on diatom biostratigraphy from at least two of these cores, resolving the position of first and last occurrence datums relative to paleomagnetic tie points to refine the age ranges of key taxa that are currently subject to significant uncertainties.



This project is ideally suited to a student who's interested in (micro)paleontology and biostratigraphy and enjoys microscope work. Depending on student interest, it could be expanded to incorporate all three cores, and/or to include a global constrained optimization modeling component integrating new and existing sites through co-supervision with collaborators at Victoria University of Wellington and GNS Science.

Post-graduate projects with James Scott

I am happy to supervise projects related to metamorphic and igneous petrology, geochemistry and mineralization. Projects can range from field-based to lab-based. The list below comprises some examples of possible projects, but it is often easier to shape a project around a student - so the list below is just some ideas that could be substantially reshaped if need be.

Mantle under the San Francisco Craton (South America)

A suite of peridotite xenoliths from diamondiferous kimberlites from this craton provides a first opportunity to characterize the ancient history of this mantle. Fundamental global questions remain about how old is the mantle under South America and has portions of it been stable since the Archean? What is its evolution?

- Project would have no fieldwork (sorry…) but would involve mineral and isotope characterization of the rare specimens of mantle material that are available.
- Mineral chemistry, osmium isotopes, oxygen isotopes.

Cretaceous mantle under in Westland

Peridotite xenoliths occur in several locations in the Westland area and are very poorly documented. However, they represent a very rare opportunity to examine the evolution and composition of the mantle under western Zealandia just before it broke away from Gondwana. What is the composition of that mantle? How does it compare to elsewhere in New Zealand? How old is it?

- Fieldwork would involve collection of material, with careful laboratory work needed to characterize peridotite xenolith compositions.

Thermal and isotopic variations in the Otago Schist

The Otago Schist in the South Island of New Zealand is a world-renown metamorphosed accretionary prism that formed on the Mesozoic paleo-Pacific Gondwana margin. It has long been considered a polyphase prograde metamorphic belt that reached upper greenschist facies; however, the thermal evolution is not well understood.

- Characterise the trace elements and U-Pb, Sr-Nd and Sm-Nd isotopes of titanite, monazite and other accessory phases across the Otago Schist, with the purpose of understanding the thermal and isotopic variations formed during progressive metamorphism.

Lower crust of the North Island and South Island

What is the composition and age of the lower crust under the South and North Islands? Using xenoliths in volcanic rocks, the project would attempt to characterize the composition and evolution of the lower crust under Zealandia.

- Determine when granulite facies metamorphism occurred by U-Pb isotopes, assess the P and T of metamorphism, establish how metamorphism tectonically fits into the history of Zealandia, and how the crust has played a role in the surface tectonics of Zealandia.

Paleozoic metamorphism in Zealandia

New Zealand's Western Province exposes two major metamorphic events: a Cretaceous and a Paleozoic event. The Paleozoic event (Tuhua Orogeny) appears to have been of high temperature and associated with and could be related to thinning of the lithosphere on the Gondwana margin.

- Fieldwork to collect rocks in Fiordland, followed by labwork to characterize that metamorphism. Perhaps some isotopic work to establish precisely when metamorphism occurred.

Alteration at Globe-Progress (Reefton, Westland)

The alteration of the wall rock around the large mineralized shear zones is poorly documented but there are hints that there are pathfinder minerals present

- Sample drill cores from these mine sites and then look in detail at the geochemistry and composition of the accessory minerals present. Analysis would be by scanning electron microscopy and then by laser ablation inductively coupled plasma mass spectrometry for trace elements and sotopes.

Environmental geochemistry

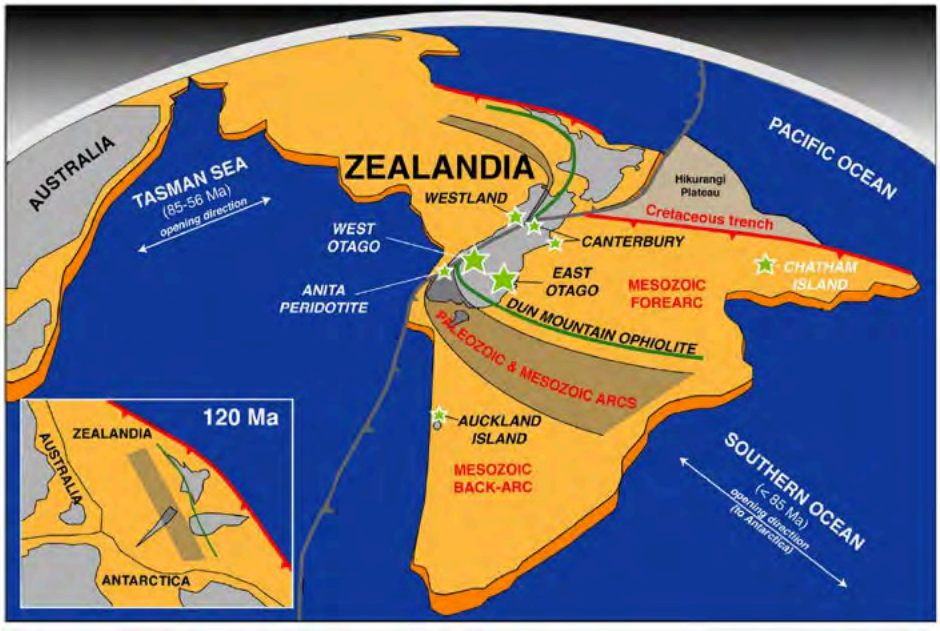
Mine sites are interesting places for environmental geology, and there are several topics of that could be worked upon. Recent projects have involved quantifying sulphate levels emanating from waste rock piles at Macraes goldmine, and the mobility of modern and historic arsenic, as a byproduct of mineralized rocks. These projects can be expanded upon.

Other mineralisation-environmental topics include gold or scheelite occurrences in the South Island

Thermal change and mineralogy of the K-T boundary in Westland

In some places in Westland, the K-T boundary occurs in terrestrial coal measures. The boundary is defined by an iridium anomaly that originates from the meteorite that vaporised. What are the mineral phases at this boundary that host the iridium? Is microdiamond present? This would be complemented by a biomarker analysis of the carbonaceous material on either side of the boundary.

- Fieldwork to collect material, lab work to characterize it.



Possible postgraduate projects/themes in 2021
Steven Smith (and others)

1. Carbonation reactions in serpentinite and peridotite in the laboratory (potentially more than one project)

Steven Smith and Matthew Tarling

In-situ (and ex-situ) carbonation reactions are proposed as one possible pathway towards lowering atmospheric CO_2. These reactions involve conversion of gaseous CO_2 in to solid carbonate minerals (e.g. magnesite and calcite). The reactions occur in natural rocks and have been widely studied in the laboratory. Reaction rates are controlled by complex interactions between intrinsic (e.g. grain size, porosity) and extrinsic (temperature) properties; many of the details are poorly resolved but extremely important if this is to become a viable future pathway. The student(s) will perform hydrothermal reactions using a simple autoclave setup inside a tube furnace at temperatures of up to 200℃. Initial results indicate that carbonation reactions occur on laboratory timescales (<weeks/months) in fine-grained or heavily fractured serpentinite and olivine. Projects will investigate the relationships between reaction rates, textural and mineralogical evolution of carbonate phases, and rock fabric (e.g. foliation spacing), grain size, and serpentine variety. Projects will involve experiments, followed by sample characterization using SEM, geochemistry, and Raman Spectroscopy.

2. Reacting to save the world (in Southland and Otago?)

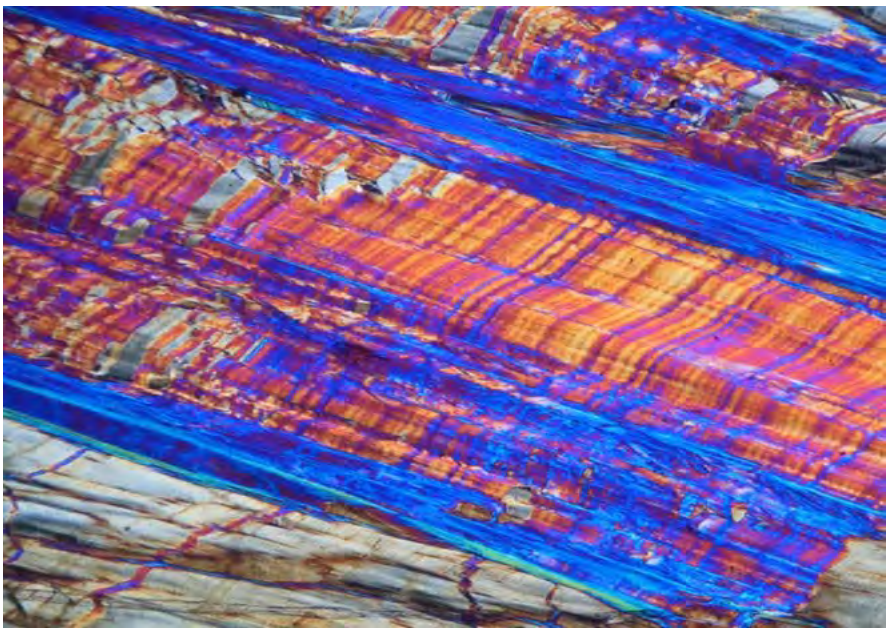
Steven Smith, Matthew Tarling and others

Successfully converting atmospheric CO_2 in to solid carbonate minerals requires the correct parent lithologies. Experimental and field-based studies around the world have shown that carbonation reactions occur readily in mafic and ultramafic rocks, given the appropriate conditions. If New Zealand is to play an important role in future CO_2 fixation projects, we need to know: where the right parent materials are; in what volumes they exist; what their textural, physical, and mineralogical characteristics are; and where they can be accessed with minimal environmental disturbance. Southland and Otago contain abundant mafic and ultramafic rocks, including in the world-famous Dun Mountain ophiolite belt. This project represents the first step in a feasibility study investigating the distribution, volumes, and characteristics of lithologies that could potentially be used as parent rocks in CO_2 fixation schemes. The project will begin with a GIS-based analysis of the spatial distribution of appropriate parent rocks based on existing data, layered together with maps showing existing or potential infrastructure, as well as areas of land with special status (e.g. conservation land). These maps will provide the basis for volume estimations. Once the maps are produced, field sampling and synthesis of existing data will provide information on rock mineralogy, texture, porosity, and permeability, from which a feasibility analysis can be carried out in terms of potential reaction rates and volumes of stored solid CO_2. The results of this project will provide an important framework for future decision-making if and when pilot projects for CO_2 fixation in NZ (or related research) become a reality.

3. Multi-scale magnetic properties of serpentinites

Steven Smith, Christian Ohneiser, Matthew Tarling

When serpentinite forms from peridotite (e.g. in shear zones; in the mantle wedge), a common accessory phase is magnetite (up to 15 wt%). Production of magnetite drastically changes the magnetic properties of the rock. This is useful because magnetic studies can be used to track reaction progress, and to understand how the distribution and concentration of magnetite changes during deformation. This project will use magnetic datasets collected over a range of scales to quantify the magnetic properties of variably- and fully-serpentinized peridotites from the Dun Mountain Ophiolite Belt. Emphasis will be placed on tracking the evolution of magnetic properties during fabric evolution in serpentinite shear zones. The student will collect and analyze magnetic datasets at the regional scale, field-scale (using a field magnetometer), and the lab scale. This will be accompanied by detailed mineralogical and textural characterization of the serpentinites.



Late Quaternary activity of the Pisa Fault, Central Otago.

MSc or PhD

Supervisor: Mark Stirling

Description: The Pisa Fault runs along the western edge of the upper Clutha Valley, and is responsible for uplift of the Pisa Range to over 1800 m elevation. Despite the proximity of this reverse fault to Cromwell, Wanaka, and the Clyde Dam/Lake Dunstan, the fault has never been studied to quantify its late Quaternary earthquake activity and seismic hazard. The fault activity will be constrained by a combination of LiDAR, field mapping, fault trenching, and cosmogenic dating of faulted terrace surfaces. Preparation of a trench log, and interpretation of earthquake magnitude and recurrence interval will be the main outputs of the study. **Funding** for the study will be provided by Contact Energy Ltd, the current owners of the Clyde hydrolectric dam.

Recommended preparation: GEOL x65 (negotiable).

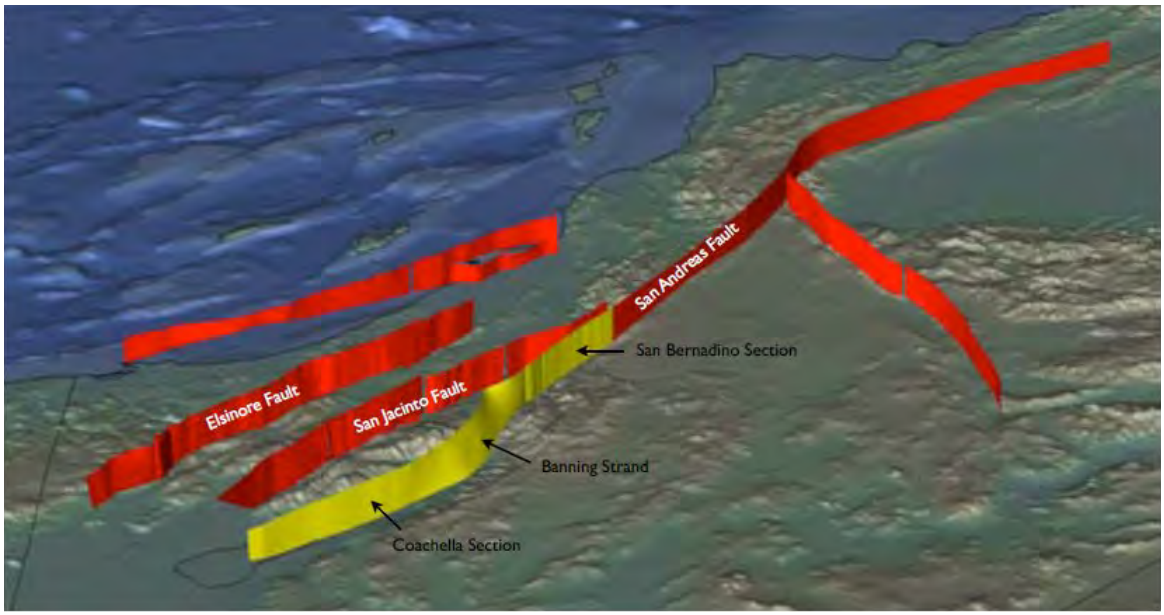
Earthquake rupture simulations for New Zealand.

MSc or PhD

Supervisor: Mark Stirling

Description: The project will contribute to the development of a computer-based earthquake rupture simulator for New Zealand, and involve the development of methods to test and evaluate catalogues of simulated earthquake ruptures across New Zealand. The candidate will interact with a multidisciplinary team of earthquake geologists, geodynamic modellers, seismologists and statisticians from GNS Science and the Universities. The project will be **financially supported** by the Resilience to Natures Challenge (RNC).

Recommended preparation: Suited to someone who is computer literate (Python, Matlab experience desirable), and has basic statistics abilities.



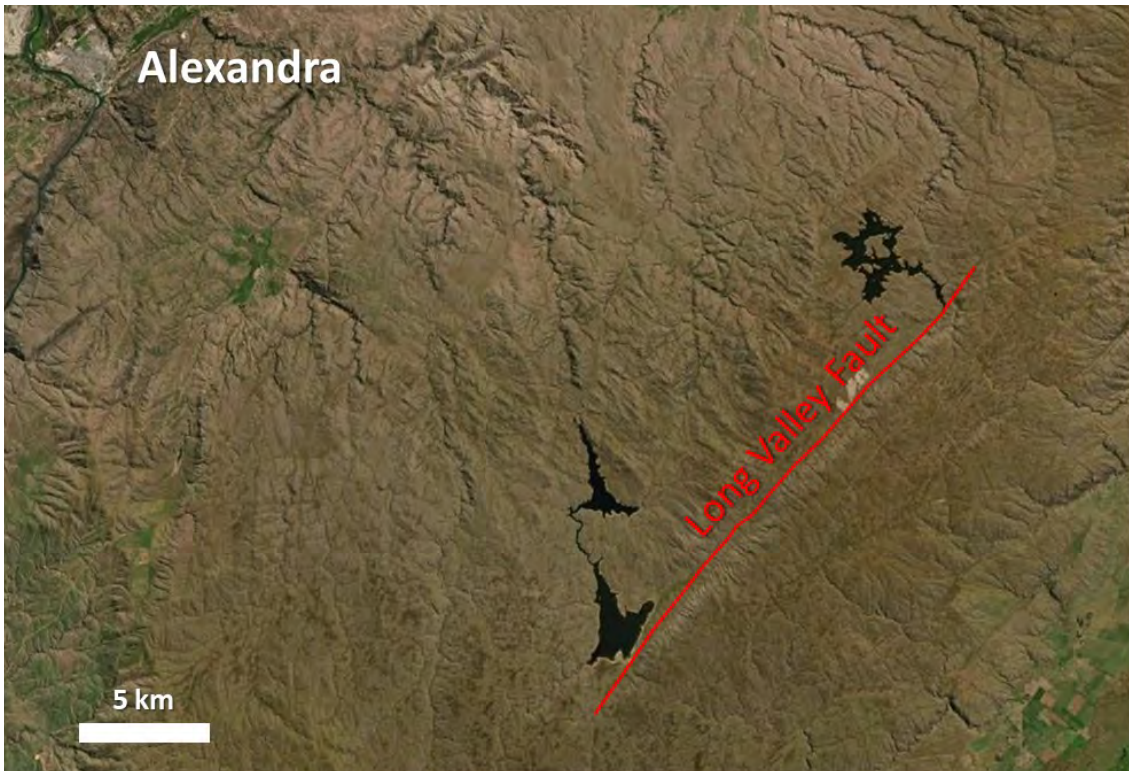
Late Quaternary activity of the Long Valley Fault, Central Otago.

BSc(Hons) or MSc

Supervisor: Mark Stirling

Description: The Long Valley Fault runs within the hills southeast of Alexandra, between Poolburn and Manorburn reservoirs. The reverse fault is sharply defined in the landscape, giving the appearance of considerable late Quaternary activity. The fault activity will be constrained by a combination of LiDAR (if available) and fault trenching. Preparation of a trench log, and interpretation of earthquake magnitude and recurrence interval will be the main outputs of the study. **Funding** for the study will be provided by Contact Energy Ltd, the current owners of the Clyde and Roxburgh hydrolectric dams.

Recommended preparation: GEOL x65 (negotiable).



Surtsey volcano's diatreme

A postgraduate research opportunity at the University of Otago.

Details

Academic background	Sciences
Host campus	Dunedin
Qualifications	Postgraduate Diploma, Honours, Master's, PhD
Department	Geology
Supervisor	Professor James White

Overview

In late 2017 Surtsey volcano, the type example of an island-forming explosive eruption, was cored by the International Continental Scientific Drilling Program.

One core targets the internal structure of the volcano. It was drilled at an angle and terminates at a depth well below the pre-eruption seafloor, but contains only primary volcaniclastic deposits, hence indicating that the vent structure below Surtsey extends at least 100 m below the original seafloor.

This project will investigate the core, including microtextures, particle shapes, thermal indicators, etc., with the aim of understanding the processes that excavated the vent, the timing of excavation, and the effects of excavation on the eruption.

The work will be linked with other projects being undertaken by an international group with bases in Iceland, the US, and Europe, and is likely to involve travel to international labs and the core repository in Reykjavik.

Effects of dike/fissure-wall properties on near-surface magma transport and eruption: An experimental approach using molten wax

A postgraduate research opportunity at the University of Otago.

Details

Academic background	Sciences
Host campus	Dunedin
Qualifications	Master's, PhD
Department	Geology
Supervisor	Professor James White

Overview

A postgraduate research opportunity is now available in the Department of Geology, at the University of Otago, New Zealand.

An experimental approach using molten wax will be employed to identify the effects of dike/fissure-wall properties on near-surface magma transport and eruption.

Supervisors

Dr Marco Brenna

BSc(W Aust) PhD(Massey)

- Igneous petrology and geochemistry
- Volcanology
- Magma ascent dynamics

Professor R Ewan Fordyce

BSc PhD(Cant) FRSNZ

- Vertebrate paleobiology
- Systematics and phylogeny of Cetacea (whales and dolphins)
- Cretaceous-Cenozoic paleontology and stratigraphy
- Paleoceanography and paleoclimates

Associate Professor Andrew R Gorman

BSc(Calgary) PhD(Br Col)

- Geophysics
- Crustal controlled-source seismology
- Marine seismology
- Gas hydrates

Dr Candace E Martin

BS(N Carolina) MPhil PhD(Yale)

- Environmental geology
- Biogeochemical cycles
- Radiogenic isotope and trace element geochemistry

Dr Christopher Moy

BSc(Union College, Schenectady) MSc(Syracuse) PhD(Stanford)

- Paleoclimatology
- Sedimentology
- Geochemistry

Dr Christian Ohneiser

MSc PhD(Otago)

- Paleomagnetism
- Paleoclimate/ocean reconstructions
- Antarctic climate evolution

Dr J. Michael Palin

BA(Calif State Fullerton) MS(New Mexico Tech) PhD(Yale)

- Mineralogy and petrology
- Geochronology and isotope geology
- Mineral deposits

Professor David J Prior

BSc(Wales) PhD(Leeds)

- Ice microstructure and mechanics
- Ice sheet and glacier dynamics
- Structural geology and tectonics

Dr Christina Riesselman

BA (Nebraska-Lincoln) PhD (Stanford)

- Cenozoic paleoceanography and paleoclimate
- Antarctic climate evolution
- Micropaleontology (diatoms)
- Geochemical proxies of paleoenvironmental change

Associate Professor James Scott

PhD(Otago)

- Meteorites, solar nebula and planetary geology
- Earth's mantle composition, history, melting
- Metamorphism, mineralisation and fluid flow
- Subduction zones and element redistribution
- Environmental geochemistry
- Zealandia's tectonics

Dr Steven A F Smith

MSci PhD(Durh)

- Structure and mechanical properties of fault zones
- Fault rock microstructure
- Deformation experiments
- Structural Geology

Professor Mark W Stirling

BSc MSc(Otago) PhD(Nevada)

Chair of Earthquake Science

- Multidisciplinary seismic hazard modelling
- Seismotectonics
- Earthquake statistics
- Tectonic geomorphology

Professor James D L White

BA BSc(TCU) MSc(Missouri) PhD(UCSB)

- Subaqueous and subglacial eruptions
- Explosive basaltic eruptions
- Shallow intrusions
- Volcaniclastic sedimentology

Some words from current and recent students

Lauren Tooley BSc (Hons) Graduate 2016

'My favourite thing about my job is the variety in the tasks I get to do. One day I'll be working on maps and reports for a gold project, the next day I'm on the phone with the a permit holder of a tungsten exploration project. My BSc(Hons) project taught me how to manage my time effectively which is extremely important when your hours of work are charged out to a client'

Lauren completed her degree on ice physics in 2016 . Now she works in Dunedin for RSC Mining and Mineral Exploration as a geologist.

Alastair King MSc student

Alastair's project involves looking at a very high grade, high angle gold bearing vein underground at Macraes. This vein, named the 3Black, is currently being mined and contains both refractory gold and free gold which can be seen in hand specimens. The vein is somewhat anomalous and its structural setting during formation is a question that Alastair would like to answer.

"I like the fact that my project is based at an active mine site as I am gaining experience while studying, plus seeing gold is always exciting!"

Tom Dwight BSc (Hons) Graduate 2016

'I love working in the exploration industry because we are constantly problem solving. It is our job to understand the deposit and try figure out what is going on. Completing my honours project has taught me how to think critically about a geological problem. This is a very valuable skill and gives me the opportunity to apply myself to different projects.'

Tom completed his degree in 2016 on Fiordland matamorphic rocks. Now he works for a small exploration company called Explaurum L based in Australia

Rosie Cole PhD student

Rosie is investigating volcanic eruptions that occur beneath ice sheets, using Tongariro and Ruapehu volcanoes as case studies. Rosie has carried out extensive fieldwork mapping the ancient deposits which show evidence for enhanced cooling and signicant water-magma interaction, in order to understand the physical eruption and emplacement mechanisms of volcanic products formed in these environments.

"I love my project because I spend my summers living and working in one of New Zealand's most beautiful national parks and I have crossed into several other disciplines including structural geology, paleoclimate and paleomagnetism."

@OtagoGeology

#OtagoGeology