ART+SCIENCE
EARTH: CAUGHT IN STONE

14 Manu Berry, *Penguins Diving in Deep Time*.

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OVERVIEW: "EARTH: CAUGHT IN STONE" ART+SCIENCE EXHIBITION, 15-22 MAY 2021, DUNEDIN COMMUNITY GALLERY

Curator: Pam McKinlay

This exhibition brought to a conclusion the eighth Art+Science project. After a false start (the exhibition was cancelled during the 2020 Covid-19 lockdown), the Art+Science team reconvened to bring the project to a successful conclusion in 2021. As in past years, artists joined with scientists, individually or in small groups, to develop artworks responding to the project theme, which in 2020 was "earth." We were fortunate to work with some outstanding researchers from GNS Science, the University of Otago (from the Geology, Geography, Zoology and Marine Science departments) and the Otago Regional Council.

Earth sciences, as defined in *The Oxford Companion to the Earth*, encompass fields of enquiry ranging from "volcanoes to flood plains, diamonds to meteors, deserts to deep seas."[1] The relevant disciplines include geology, climatology, mineralogy and oceanography, and extend from mapping the features of the third rock from the sun to journeys to the centre of the earth. Earth sciences explore the formation of rocks, as they are layered across geologic time, restless under pressures, ruptures and constant change. They engage with the macro and the micro, with chaos and order, and with the evolution of complex life forms to the extinction of species throughout deep time.

Then there is the situation of us humans and how our planet has made us. The interconnectedness of earth systems and our use of natural resources has changed the course of our histories and cultures. And what will earth horizons would look like from the next geological era, since people have become an earth-shaping force in the Anthropocene?[2]

The "Earth: Caught in Stone" exhibition was loosely curated into three groupings of work which explored ideas at the 'macro' and 'micro' scale and 'evolution' across time and place. Narrative themes explored in the 'macro' grouping included: Zealandia, the eighth continent of the world (GNS); geospatial data and bathymetry of Antarctica and Zealandia (GNS); coastal and river erosion (Geography); ecosystems soil bioengineering (Zoology and ecosystems consultants); iceberg debris in Antarctica (Geology); sedimentology and current ripples, modern and ancient (Geology); volcanology (Geology); "What lies beneath Dunedin?" – a shallow groundwater data-collection and core-sampling project (ORC); and geological mapping (GNS).

In the 'micro' grouping topics included: skeletal geochemistry and biomineralisation (Oceanography); diatom formations (Geology); rock fundamentals – zircons (GNS and Geology); and Earth's ever-changing magnetic field (Otago Paleomagnetic Research Facility). The 'evolution' projects included Zealandia's past biodiversity (paleobotany to paleoecology), and speciation and the phylogeny of Zealandia dolphins (palaeontology); petrified wood from Gondwana to Zealandia (Geology); and the non-linear evolution of *Kumimanu*, a genus of giant penguins (palaeontology).

"Earth: Caught in Stone" included a formal exhibition as well as a family-focussed public programme including "meet the scientist" talks, free art-making, games and other activites. The programme included "What's that Rock?" with "Dr Rock", who identified rocky treasures and found curiosities of a geological kind. A community artwork, facilitated by artist Debbie Fleming, was made from rocks decorated with words and pictures which were added to a 6-metre installation depicting a 'river of thoughts' running through the gallery. The Otago Rock and Mineral Club was on hand with a pop-up display of things to discover in your back yard or local swamps, including a table where children young and old could find a polished 'pocket rock.' Other activities included giant jigsaws (with guest artist Manu Berry) and tabletop games that could be played with pebbles – such as *mancala* (a table board made by Down the Rabbit Hole Art Collective).

Last but not least, the exhibition concluded with the "Great rock cake" bake-off. Taking the lead from the Geological Society of London's Great Geobake-off Challenge,[3] categories included Sedimentary layer cakes, Unconformity and Subduction decorated cakes, Sinkhole or Geode cupcakes, Pancake Rock-cakes, Earth Globe Mantle cake, and favourite geological-era fossil cakes. Entries were judged by a panel of revered geology cake connoisseurs and "Dr Rock," from a competition table and photographs of entries posted online. This last activity took our premise that art is an ideal way to communicate science in "digestible chunks" to a literal conclusion.

Artists and scientists alike use drawing and model-making as tools to understand how earth processes work. Discovery through observing and recording, in the lab or in the field, leads to visualisations of what goes on beneath our feet, above us and around us. In the eighth Art+Science project, "earth" was broadly interpreted as a project theme. The project was co-ordinated by the Art+Science Project 2020-2021 team led by Pam McKinlay from the Dunedin School of Art, Dr Bryce Peebles and Dr Jenny Rock. The exhibition was curated by Pam McKinlay.

The following pages capture conversations, research and encounters from several of the partnerships within the project.

With acknowledgements to Dr Jenny Rock and Dr Byce Peebles, co-coordinators in 2019-2020.

Pam McKinlay (ORCID ID: https://orcid.org/0000-0002-1731-6437) is a writer and artist with a background in applied science and the history of art. She has been the convenor of the last three Art+Science project series at Dunedin School of Art. As an artist, she works in collaboration with other artists and scientists locally and nationally in community outreach and education projects on the themes of climate change, energy, the cryosphere and ocean acidification.

1 Paul L Hancock and Brian J Skinner, *The Oxford Companion to the Earth* (Oxford, UK: Oxford University Press, 2000 and online 2003), https://www.oxfordreference.com/view/10.1093/acref/9780198540397.001.0001/acref-9780198540397 (accessed 25 April 2021).

2 J Zalasiewicz, C Waters and M Head, "Anthropocene: Its Stratigraphic Basis," *Nature*, 541 (2017), 289, https://doi.org/10.1038/541289b. In this article, the proposition that the Anthropocene be considered a formal unit in the geological timescale is assessed with respect to the requirements of the International Commission on Stratigraphy (ICS).

3 Rose Want, "The Great Geobakeoff 2020 – The Results!," *Geological Society of London blog*, blog post, 13 October 2020, https://blog.geolsoc.org.uk/2020/10/13/the-great-geobakeoff-2020-the-results/ (accessed 22 March 2021).

ARTISTS AND SCIENTISTS – EXHIBITION CAPTIONS

1 Belinda Smith Lyttle and Jenny Black (artists) with Nick Mortimer (scientist), *Te Riu-a-Māui / Zealandia*, triptych, printed fabric panels, 680 x 820 cm. Three panels showing different map depictions of the same area of the Te Riu-a-Māui / Zealandia continent. Left: land and ocean only; centre: seafloor plateaus, basins, ridges and trenches; right: detail of geology.

2 Down the Rabbit Hole Art Collective 2021 (Pam McKinlay, Henry Greenslade, Leonora DaVinci), with Belinda Smith-Lyttle (scientist), *Emergen(t) Seas* – The Bedrock of Antarctica, triptych, light boxes, 680 x 1016 mm. Two of the light boxes were woven interpretations of the Antarctic Plateau and an escarpment in the Transantarctic Mountains. The centre box contains an LED light-work with an overlay of a map of Antarctica, with sea-floor bathymetry showing the relationships of the three southern hemisphere continents.

3 Sarah Shackleton (artist) with Simon Cox (scientist), multi-media installation, *Tūrangawaewae* 118 x 168 cm, based on five large acrylic-on-canvas works (each 130 x 195 cm, currently on exhibition in Spain).
An exploration of our connection to the land and empowerment by it, enhanced by an understanding of earth science. Five large paintings were created in response to a scientist's stream-of-consciousness and geological thoughts while 'reading' landscapes lying to the north, east, south and west of Warrington, Otago, during coastal walks. The dynamic process of painting, while online geology lectures were projected onto the canvas, was compiled into video recordings which were projected back onto the canvas.

4 Geoff Wyvill (artist) with Jasmine Mawson (scientist), *About Time*, wooden clockwork installation, 400 x 300 x 150 mm. Two images of a rock formation in its context now and 260 million years ago are engraved on opposite sides of a Jacob's Ladder. The images are displayed alternately, changing every five minutes or so.

5 (5A) Vivien Dwyer (artist) with Faye Nelson (scientist), *Seafloor Spread*, needlework tapestry, 830 x 590 mm. Stripes of normal polarity and reversed polarity alternate across the ocean bottom. These magnetic patterns in sea-floor spreading remain some of the strongest evidence for the theory of plate tectonics.
(5B) Also: Faye Nelson (artist and scientist), *Paleomagnetist's Field Book*, machine stitching and appliqué on fabric; wool, cotton and acrylic paint, 240 x 190 mm (open). Portrays the nature and timing of Earth and ocean processes through magnetic minerals.

6 Jessica Ritchie and Craig Cook (artists) with Michael Palin (scientist), *Standing Still at Boatman's Harbour*, wall rubbing, cyanotype and painting on paper, 1520 x 1040 mm. Drawing and video created at Boatmans Harbour in Oamaru.

7 Christine Keller (artist) with Adam Martin (scientist), *Otago Schist*, two hand-dyed, hand-woven textile panels, 780 x 1950 mm and 740 x 2100 mm, using merino from Armidale in Central Otago and elsewhere, and linens and cottons as well as found yarns. The dyed warp is inspired by a microscope image of Otago schist rock from the Maniototo area under polarised light. The pink and purple stripes, which represent mica, are made from merino wool sourced from the Maniototo.

8	Katharine Allard (artist) with Sophie Briggs (scientist), *MacFarlane Ridge*, 2021, zircon ground with silverpoint drawing on paper and piqué, 420 x 594 mm (framed). Display of made and collected objects (rocks, paper, glass, clay), dimensions variable.

9	Vivien Dwyer (artist) with Daphne Lee (scientist), *Cosy Dell*, woven tapestry, embellished with small fossils from site dig, 600 x 970 mm. Cosy Dell Farm is situated at Waimumu in southern New Zealand. It was once a rocky shore ecosystem, but is now well inland. The excavation site is a rarely preserved fossil record of intertidal and shallow subtidal biota, which reveals the existence and extent of the maximum marine transgression during the Oligocene.

10	Katherine Steeds (artist) with Abby Smith (scientist), *Small Dreams of Grandeur*, slip-case book hand-made from cotton rag paper, accordion structure, printed then hand-worked using collage, watercolour, inks and graphite, 31 x 15 x 3 cm (closed in box), 31 cm x variable width (open). An exploration of bryozoan fossils.

11	Kate Elder (artist) with Bryce Peebles (scientist), *Biomineraliser of the Year*, mixed media low relief sculpture, 800 x 300 x 70 mm. Giant cross-section of a shell, showing its make-up in many layers. The construction materials were taken from the artist's immediate environment, mimicking the way in which shells build themselves with minerals from the water around them.

12	Pam McKinlay (artist) with Mathew Vanner (scientist), *Petrified Sampler*, woven panel, single ply wool and rayon, silk, 500 x 2500 mm. Based on transparencies of microscope slides of fossil wood samples from the Araucariaceae, Casurinaceae and Myrtaceae families. The artist's woven and tapestry sampler panels were inspired by fine slivers of fossilised wood prepared for microscopic examination.

13	Stella Lange (designer) with Grace Duke (scientist), *Shadows Unfocussed*, design for a handknitted hat available free at Raverly.com. Finished hat on display, 290 cm diameter, posters of diatoms. Design based on the experience of viewing diatoms under magnification through a microscope.

14	Manu Berry (artist) with Marcus Richards (scientist), *Penguins Diving in Deep Time*, three black-and-white woodcuts, 1010 x 1400 mm; three jigsaws, 1110 x 1500 mm. The woodcuts focus on the skeletal form of penguins from three different eras, with backgrounds consisting of other creatures from each era to suggest the link between evolution and environmental pressures. The blocks from these woodcuts have been cut into large jigsaw pieces to represent Marcus's process of reconstruction.

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15 Desi Liversage (artist) with Katie Matts (scientist), *Unearthing*, embroidery, 800 × 500 mm. Platydyptes is an extinct genus of giant penguin, known chiefly from the Hakataramea Valley, North Otago.

16 Meg Brassel-Jones (artist) with Emma Curtin and Henrik Moller (scientists), *Connectivity/Reciprocity*, acrylic on ply, 700 x700 mm. Dung beetles connect history, myth, science and economy. They symbolise regeneration and the restoration of life. They keep vital ecological cycles churning, build soil, disperse nutrients and play a role in protecting our streams. They improve soils to help feed people.

17 Heramaahina Eketone (artist) with Jon Linqvist (scientist), *Ripo effect*, ink on 300gsm paper and fired and glazed uku, A3 plus variable dimensions. Ancient ripples are a form of sedimentary structure in which gentle waves have left ripples across the sand and have later turned to rock, preserving the patterns of the gentle eddies made millennia ago.

18 Eden Smith (artist) with Sophie Horton (scientist), *Kaikoura Peninsula, sound work*. This piece is a response to charts showing the tidal cycles and wave intensity of an area in the Kaikoura Peninsula affected by the recent earthquakes.

19 Becky Cameron (artist) with Sharon Hornblow (scientist), *core values*, detail, monoprint and drawing on paper, 800 × 3000 mm.
This work suggests that the future of South Dunedin lies in the intersection of its environmental and human histories. The column of prints echoes the core samples that Sharon Hornblow has been using to study the massive transitions between wooded river valleys, flax swamps and ocean that the area has undergone. This is overlapped by a representation of South Dunedin, with its history of community action and its vibrant and diverse communities – strengths that can be drawn on to move forward into a new relationship with the environment.

20 Fiona Clements | Senorita AweSUMO (artist) with Christian Ohneiser (scientist), *Antarctic Terror: A Screaming Symphony of Icebergs*, performance and installation, upcycled banner, thread, wheels, cover board, wood, human potential. Lower Octagon, Dunedin.
An iceberg upcycled from local Dunedin waste materials forms the centrepiece of a chaotic performance, with audience participation. Performers and the public will come together to communicate their anxiety through vocalisation and movement, working together to acknowledge their fears and process the trauma of climate anxiety.

21 Debbie Fleming (artist) and Sophie Horton (scientist), *Travelling Stones Talk*, 'river' installation and interactive art piece, stones, paint, crayons, 1000 × 600 mm. Participants contribute to the artwork while building knowledge and ownership of their environment. Geomorphologist Sophie Horton and artist Debbie Fleming collaborate to provide a fun, interactive experience involving adults and children within a relaxed, creative learning environment.

22 Gallery activities.

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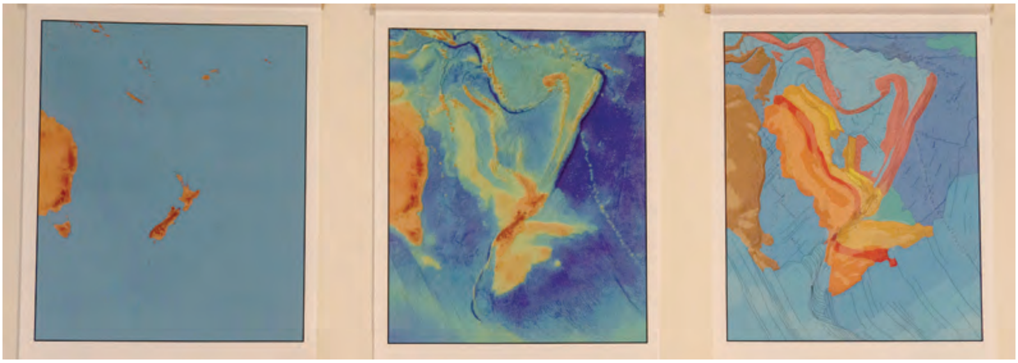
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Hazards
thermosteric sea level rise
inundation
H2O
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water vapour
Coastal erosion
non-linear ice sheet
Tūrangawaewae

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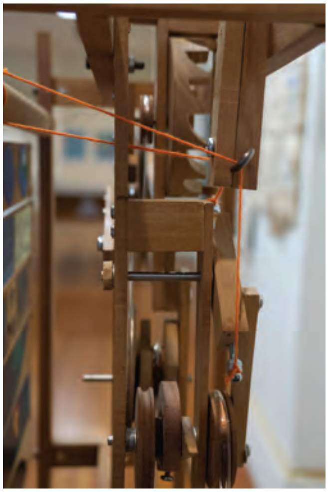

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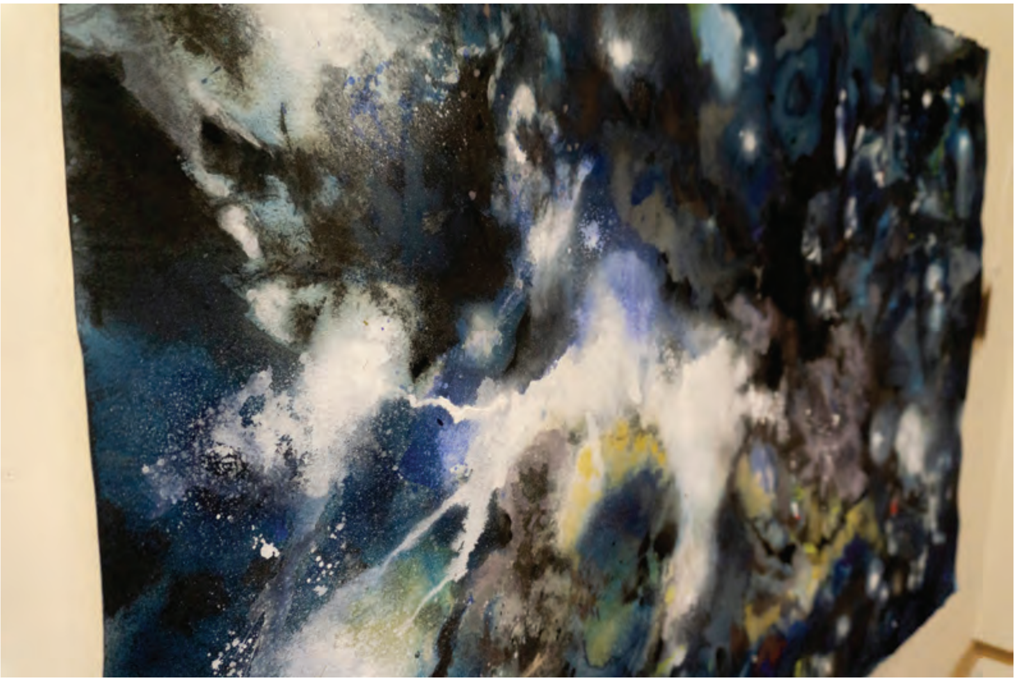

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TŪRANGAWAEWAE: AN ART+SCIENCE PROJECT

Scientist: Simon Cox
Artist: Sarah Shackleton

Tūrangawaewae is one of the most well-known and powerful Māori concepts.[1] As tūranga means "standing place," and waewae "the feet," it is most commonly translated as "a place to stand."[2] But simple translation misses a deeper spiritual meaning. Tūrangawaewae are places where we feel connected and empowered.[3] They are our foundation, our place in the world, our home. Connection to place and the whenua (land) is fundamental to Māori identity, and not unfamiliar to Pākehā. It shapes our thinking, our way of being, our priorities and values.

Connection to the land is a familiar concept for earth scientists, as it forms a large part of their daily lives and is often a raison d'être for their work. After more than three decades mapping geology and observing landscapes, the way in which Simon Cox (Principal Scientist, GNS Science) understands and 'reads' the landscape has gradually evolved. While he was initially trained to see a static, old and 'timeless land' of hard rocks and deep geological time, New Zealand's active tectonics and natural hazard events have shown Simon a more dynamic, lively and dramatic set of processes that continue to shape Papatūānuku (mother earth).

But how might the 'spirituality' of tūrangawaewae and this sense of connectedness be captured, quantified or represented? Is it possible that art can show some of the depth, complexity and layering of thought that enables scientists to feel empowered to provide recommendations and advice?

Over the past decade, science in New Zealand has also been changing and beginning to embrace a policy framework which seeks to unlock the innovation potential of Māori knowledge.[4] Vision Mātauranga,[5] a New Zealand government science policy initiative, seeks such opportunities by recognising and valuing cultural perspectives and expertise – for example, through the use of kawa (cultural practices) and tikanga (cultural principles) to examine, analyse and understand the world. Among the fundamental underlying principles of mātauranga Māori is the human element and the need to first understand the holistic interdependence between people and their environment (whanaungatanga),[6] in contrast to Western science, which typically begins the process of understanding through close observations of something, or someone, in isolation of wider systems. Among the places where whanaungatanga becomes most acutely important, deeply felt and easily explored are our tūrangawaewae.

Working at the interface of two world views should enable new ways of doing things, finding answers and problem solving.[7] The "Tūrangawaewae" exhibition explores a spiritual side of earth science and connectedness to the landscape, one that will not be found in technical scientific manuscripts and equations. As a collaboration between art and science, the concept behind it may have been complex, but its execution is relatively simple. Sarah Shackleton (visual artist) and Simon Cox (scientist) decided to use video as a way to create a combined artwork, which would tie together their shared Pākehā feeling for the land. While the world locked down and turned to online-only relationships during Covid, Simon recorded his immediate thoughts via a stream of consciousness as he looked at, and read, the landscape. Warrington Beach, where he lives near Dunedin city, provided the setting for physical walks and mental wanderings. A set of 'online lectures' were created from Simon's views to the east, south, west and north of Warrington, exploring some of the science behind tectonics, earthquakes, sea-level rise and climate change across Te Waipounamu – the South Island of New Zealand. Using these recordings, Sarah tapped into her memories of Te Waipounamu, generating the series of artworks she called "Tūrangawaewae."

Figure 1. Warrington Beach, where a number of 'stream of consciousness' lectures about the way an earth scientist views, reads and thinks about the landscape were recorded by Simon Cox.
Photograph: Simon Cox, 2020.

"As a scientist, it's my job to try and observe things differently," says Simon in the introductory lecture. "I draw on the depth of time that I have learnt through geology, think about processes and rates of occurrence, and consider how these generate hazards and impact our lives." A sunrise (Figure 1) is a beautiful, simple example of this. People tend to look at the picture and immediately say, "Oh wow, that's a cool sunrise." But actually, it's not a sunrise at all – at least no more than the earth is flat. When beautiful things like a sunrise, or landscapes, dominate our view, it's very easy to forget that we're on a huge round planet orbiting the sun and simply slowly rotating into the path of the sun's rays.

In order to (re)discover that the earth is not flat, scientists must rethink and continually test how we think about our world. That is why there is such value in the juxtaposition of different world views through Vision Mātauranga. Since earth scientists are looking at earth processes over extreme depths of time, they also develop a unique perspective on our landscape and its changes, a process which creates a very strong sense of tūrangawaewae.

Although living in Spain, on the other side of the planet, Te Waipounamu is the birthplace of visual artist Sarah Shackleton. It is a place where she has stood, where she has family and is still very connected to. The land, the mountains and the power of Te Waipounamu are central to the development of Sarah's artwork.[8] Projecting Simon's videos onto canvas, Sarah dissected his lectures into a series of complex lines, shapes, colours and textures, reconstructing the science as a chaos of layers on the surface of each painting. In the manner of a scientific experiment, Simon teased Sarah with images and views with potential to evoke an old sense of belonging. As she painted the land of her birth and layers upon layers of the science behind it, Sarah's connectedness did indeed evolve. And all the while, the artistic side of the project was both projected and mirrored in video.

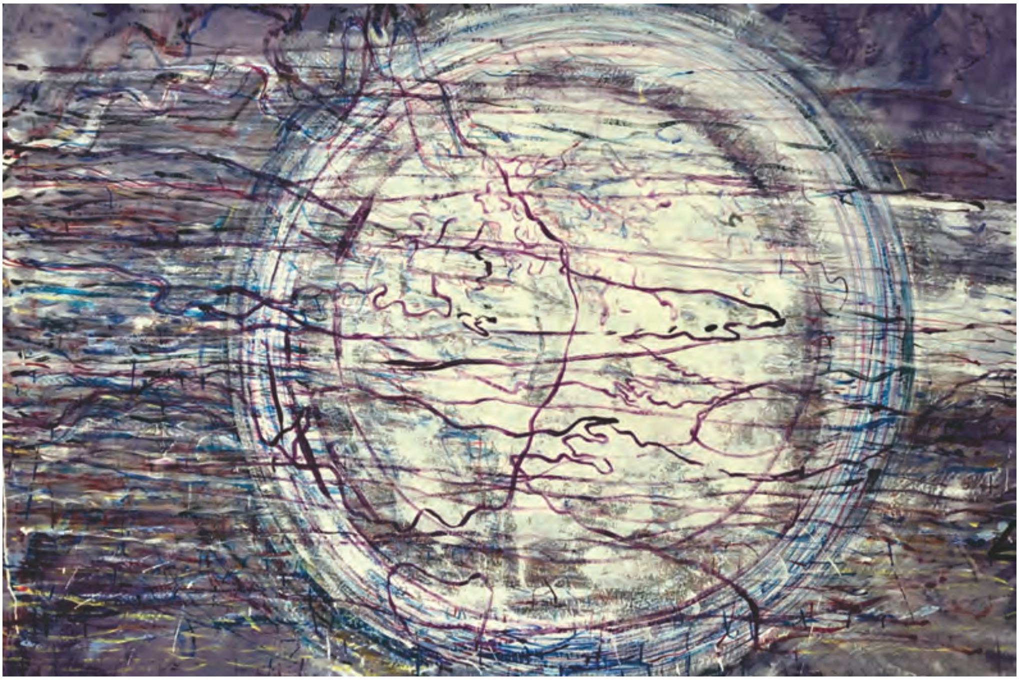

Figure 2. Sarah Shackleton, *Introduction*, 2020, acrylic on canvas, 130 x 195 cm.
Simon's video lectures were projected onto a wall and painted into five canvasses, with the evolution of each painting filmed as it was created. This work explores concepts of tūrangawaewae and connectedness with the land, our 'blue marble' and earth systems driven by the dissipation of energy.

The work *Introduction* (Figure 2) captures how many planetary-scale processes are driven by the dissipation of energy. With its incredibly thin atmospheric layer, our blue planet is delicate and vulnerable to even the slightest change. Stream-of-consciousness thought patterns follow along the lines of energy. The sun shines on the atmosphere, the atmosphere warms up, the air tries to move and takes water with it. The sea warms up, water expands, local sea levels rise, and ocean currents develop. The kinetic energy of waves and wind hit the coast and are absorbed by the land as it erodes. Earth's tectonic plates shift in response to dissipation of thermonuclear energy within the planet, causing landmasses to be uplifted, disturbing the ocean currents and atmosphere, which in turn causes rain, landslides and erosion. Aotearoa New Zealand is just a 'tiny rock' that pokes up out of the Southern Ocean into the full force of a westerly atmospheric circulation – which in turn shapes the way Te Waipounamu is eroded, deformed and uplifted, and controls our climate, the availability of fresh water, natural hazards and our ability to inhabit the land.

The works *East*, *South*, *North* and *West* (Figures 3-6) also reflect layers of geological processes and thoughts generated by the landscape and processes shaping Te Waipounamu. Keywords: blue planet, vulnerability, climate change, ice sheets, sea-level rise, groundwater, plate tectonics, volcanoes, earthquakes, rainfall, mountains, landslides, glaciers, erosion, landscape change, hazard, risk, society.

Represented by five large canvasses and digital recordings, "Tūrangawaewae" was an art and science collaboration that evolved through the heterogeneous stratification of geological processes, landscape evolution, scientific musings, online lectures, painting and drawing, digital editing and artistic expression. Transcripts of these earth science ponderings, online lectures, a compilation of the film projected in the Dunedin Art and Earth Science exhibition (17-22 May 2021) and reproductions of canvasses can all be viewed online.[9]

Figure 3.
Sarah Shackleton,
East, 2020,
acrylic on canvas,
130 x 195 cm.

East encompasses a view out across the vast, yet relatively unknown, Pacific Ocean at sunrise. The painting captures thoughts about earth's rotation, our delicate atmosphere, climate change, sea-level rise and the dissipation of wave energy by New Zealand's coastline. Looking out across the horizon generates a realisation of the incredible volume of seawater that is marching slowly towards us. There has been a massive change to the planet and we're now committed to putting up with it. You can't just run away!

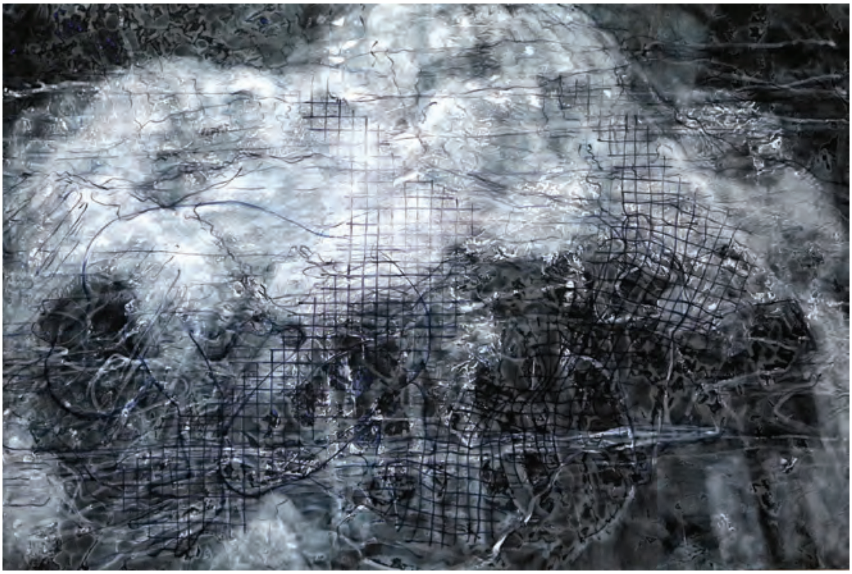

Figure 4.
Sarah Shackleton,
South, 2020,
acrylic on canvas,
130 x 195 cm.

South is generated from a view of the hills of Dunedin and the neighbouring Miocene volcano, once the site of a violent eruption dissipating energy from earth's mantle. But do the volcanic rocks and Papatūānuku hide other secrets? Geologists have tended to think of the volcano as the main local land-forming event, but the rocks are disrupted by fault lines and there is very real potential for earthquakes beneath the city of Dunedin.
Looking at the landscape, one should be concerned if the 'absence of evidence' is really 'evidence of absence!'

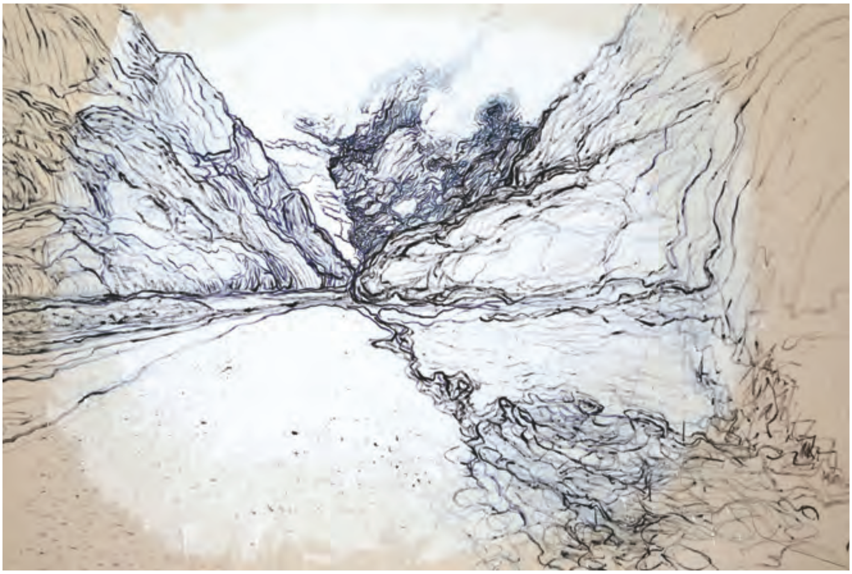

Figure 5.
Sarah Shackleton,
West, 2020,
acrylic on canvas,
130 x 195 cm.

West embraces a view of sunsets and the Southern Alps, where the geology of Te Waipounamu is shaped by the interaction between tectonic motion and atmospheric circulation. Uplift on the Alpine Fault creates our weather patterns, our clouds and rain and fundamental aspects of our climate and hydrological cycle. It has exposed schist bedrock, carries the pounamu and gold on which our country was built, and will be important for the future supply of water.

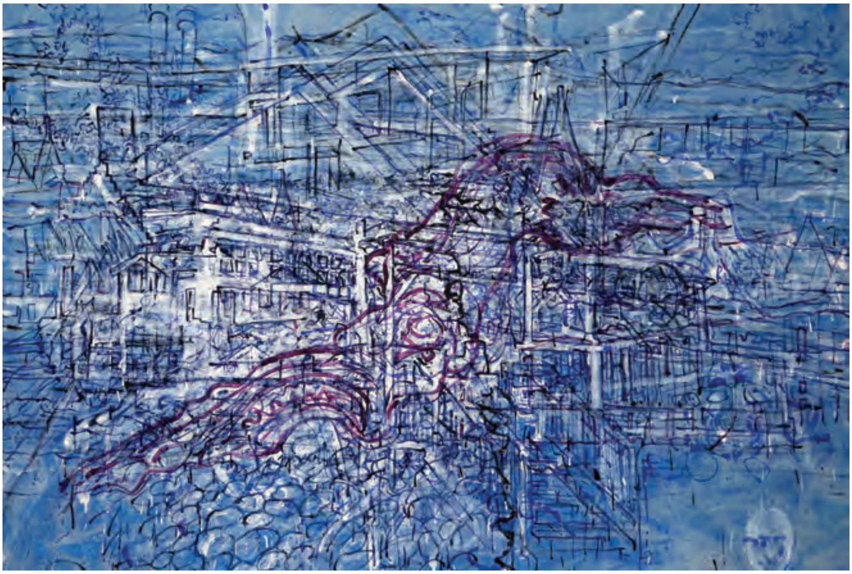

Figure 6.
Sarah Shackleton,
North, 2020,
acrylic on canvas,
130 x 195 cm.

North takes in a view of a rapidly shifting sand-spit, old marine terraces and landslides on which Otago coastal communities have been developed. The painting contains imagery of the former Seacliff Hospital, the Dunedin suburb of Abbotsford, a Warrington Beach house and a driftwood carving on the beach that is periodically exhumed by wind and shifted by waves and tide. The local sedimentary rocks are weak and slippery, causing mobility and interactions between the land and the sea.

Sarah Shackleton (www.sarahshackleton.com) is a visual artist who was born in Dunedin, but has been living and working in Zaragoza, Spain, since 1991. From early on, since the 1980s, Sarah has looked to the land and mountains for inspiration in her artwork. Already then, Sarah sought to uncover some of the energy lying under the surface of the land and capture the forces leading to the formation of the mountains in the Southern Alps of New Zealand in her series of large gestural landscapes, *Core of the Land*. Sarah's work, which explores the interaction of nature and culture, has been regularly exhibited in Spain. She completed an individual show, "Blue: The Way it Was," in Zaragoza on 15 May 2021. The "Tūrangawaewae" series of canvases and vídeo formed part of the group show "¿S.A. de prójimos?"in Zaragoza in April 2021, an exhibition that brought together art and science. Sarah is an integral part of the local art community in Zaragoza, but still looks for connections to her homeland.

Simon Cox (ORCID ID 0000-0001-5899-8035) is a Principal Scientist at GNS Science in Dunedin. He has a deep interest in the outdoors, where his passions for climbing, skiing, surfing and exploration are regularly fulfilled. His geological career was initially dominated by interests in tectonics, the Southern Alps, Antarctica and mineral exploration. During the past decade he has been more focussed on geological hazards – landslides, the Alpine Fault, earthquake hydrology and shallow groundwater. A recipient of multiple national geoscience awards, Simon maintains close ties with local iwi/Māori, supervises research students, collaborates internationally and is cited globally. He is widely recognised as a public speaker and communicator of science, with a wide network of science end-users.

1 "Tūrangawaewae – A Place to Stand," *Te Ara: The Encyclopaedia of New Zealand*, https://teara.govt.nz/en/papatuanuku-the-land/page-5 (accessed 21 June 2021).

2 *The Māori Dictionary*, s.v. tūrangawaewae, https://maoridictionary.co.nz/ (accessed 21 June 2021).

3 *Te Ara*, "Tūrangawaewae."

4 Ministry of Research, Science and Technology, *Vision Mātauranga: Unlocking the Innovation Potential of Māori Knowledge, Resources and People*, 2007, https://www.mbie.govt.nz/assets/9916d28d7b/vision-matauranga-booklet.pdf (accessed 21 June 2021).

5 Ministry of Business, Innovation and Employment, "Vision Mātauranga," 2018, https://www.mbie.govt.nz/science-and-technology/science-and-innovation/agencies-policies-and-budget-initiatives/vision-matauranga-policy/ (accessed 21 June 2021).

6 Rauika Māngai, *A Guide to Vision Mātauranga: Lessons from Māori Voices in the New Zealand Science Sector*, 2020, http://www.maramatanga.co.nz/sites/default/files/Rauika%20Ma%CC%84ngai_A%20Guide%20to%20Vision%20Ma%CC%84tauranga_FINAL.pdf (accessed 21 June 2021). See the comments by Sir Mason Durie, p. 25.

7 Ministry of Research, Science and Technology, *Vision Mātauranga*; Rauika Māngai, *A Guide*.

8 https://www.sarahshackleton.com

9 https://www.sarahshackleton.com/index.php/project/turangawaewae/

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Art+Science Project Report: Part 3

SMALL DREAMS OF GRANDEUR

Scientist: Abigail Smith
Artist: Katherine Steeds

STONE, SEAWATER, SHELLS, STONE:

Abigail Smith

People ask, "and what do you do?" I could say I'm a carbonate geobiochemist, but that doesn't explain much. Often I just say "I study shells." But really, I study the journey from stone to seawater through shell back to stone. It takes some geology, a bit of chemistry and a fair understanding of marine biology to get at the guts of this process. I'm a jack-of-all-trades, as long as it involves calcium carbonate.

From Stones to Seawater

Chemicals get into the sea mostly from weathering – rocks wear down and dissolve; and elements like calcium find their way into waterways, and eventually the sea. After sodium and chloride (salt), calcium is one of the most common elements dissolved in seawater, usually hovering about 0.04 percent.[1] That doesn't seem like much, but there's a lot of seawater, so there's a lot of calcium. All living things need and use calcium. In fact, it's the most common mineral in people, in bones and teeth.[2]

From Seawater to Shells

If you combine calcium with a carbon and three oxygens, you get calcium carbonate ($CaCO_3$). This common mineral is known by lots of names: lime, chalk, shell, limestone, calcite, onyx, marble. There's plenty of carbon and oxygen in the sea, so making calcium carbonate from seawater is something many creatures do. They make shells, skeletons, eggshells: in myriad forms, all complexly engineered, all beautiful.

Think about a delicately-pigmented snail shell, produced by a squishy mollusc for protection. Consider the thick ropy white castle of the barnacle, complete with doors that open and close. Imagine the iridescent glory of the inside of a pāua shell, or the elegant spines of an urchin. All calcium carbonate, all harvested from seawater and pressed into service (Figure 1).

Special Shells

It was during my PhD study in the early 1990s when I first encountered a very poorly known, but simply lovely group of critters – their delicate skeletons captured me with their versatility, their regularity and their beauty. Let me tell you about bryozoans.

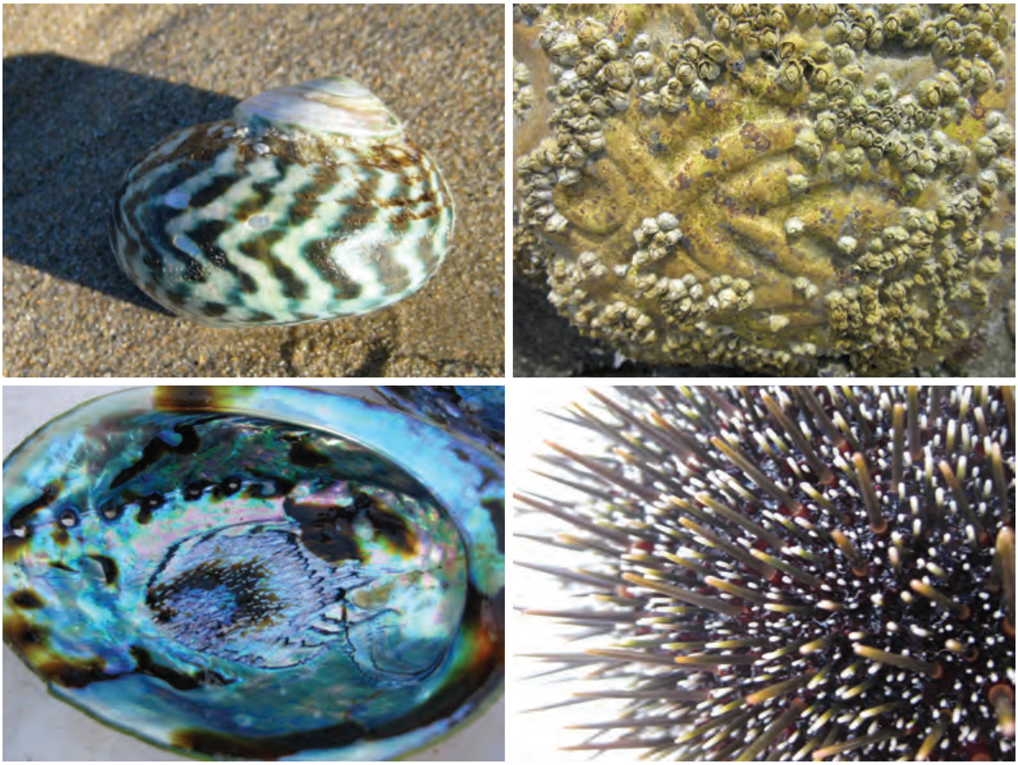

Figure 1. Many amazing ways animals can make seawater into shells.

The name bryozoans means "moss animals," because they are tiny animals who group together to make colonies that are vaguely plant-like. Another name for them is "lace corals," because of their net-like forms and their colonial lifestyle – they are not really related to corals. They aren't edible, they are very small and they often live in deep water or under rocks – so they aren't known to every beachcomber.[3]

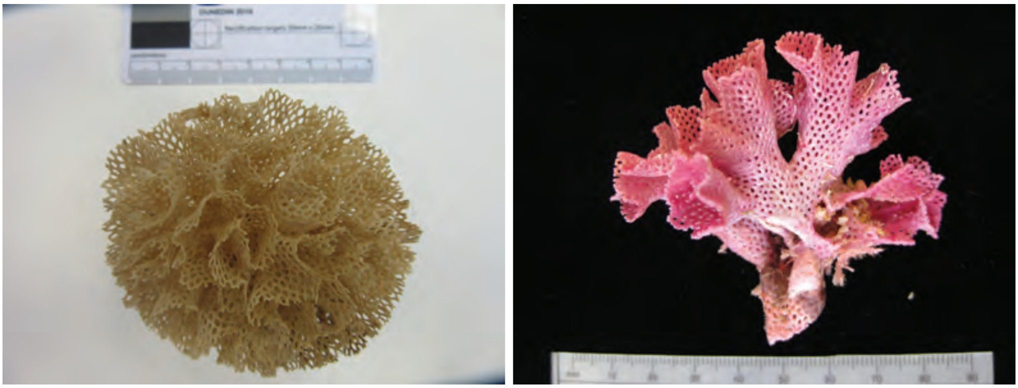

Figure 2. Examples of "lace coral" or a bryozoan colony – about 12cm across.
Made of millions of tiny identical boxes, each with a single individual animal living inside.

Each tiny individual bryozoan is less than 1mm across, and each of them makes a little box of calcium carbonate, connected via tubes and pipes to their neighbours. They form a colony, like a tiny apartment building – or maybe more like a mitten, where each knitted stitch has its place and role to play (Figure 3). Inside each box is a tiny critter (a polypide), which emerges with tentacles waving to catch minute food particles. Some of them don't eat – they defend the colony, or they reproduce – and are supported by their neighbours.

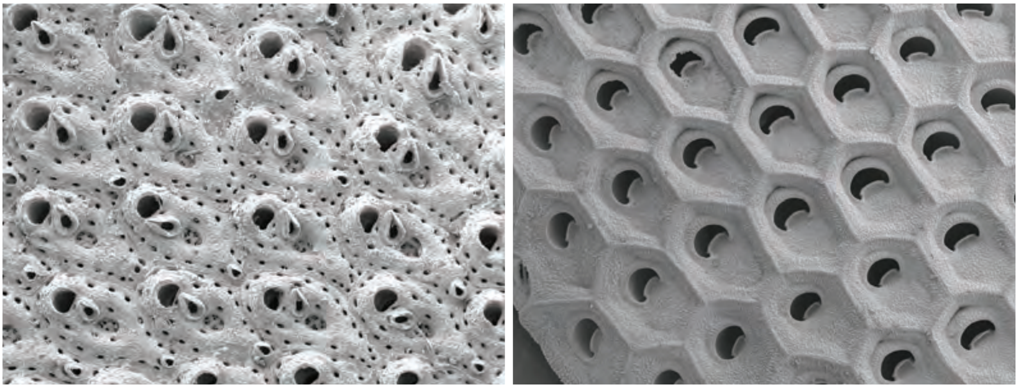

Figure 3. Close-ups of bryozoan skeletons. Each little oval box is about 0.5mm long,
and each hole is the door for a tiny polypide to come out.

Bryozoans are not very large or abundant in the northern hemisphere where most textbooks are written, so they are classed as a "minor" group. But in Zealandia and Australasia they are abundant, large and diverse. Zealandia alone might have a thousand species of living bryozoans, making them the fifth-most diverse group in our seas.[4] And yet most people have never heard of them. You might call them marine biology's best-kept secret!

Figure 4. Left: Specimens of Oamaru stone in a museum collection.
Right: St Luke's Church in Oamaru, made entirely of Oamaru stone, full of bryozoans.

From Shells to Sand to Stone Again

When bryozoans die, the shell remains become sand. South and east of the South Island, in water about 60-100 metres deep, lie thick deposits of bryozoan-dominated sediments. They are loose at the top, but near the bottom they are compressed and cemented, becoming limestone.

Bryozoans have been producing shells from seawater for millions of years. They are common and abundant fossils around the world. We know them here as the major component of Oamaru stone, the white limestone used in Oamaru's historic buildings, the Dunedin railway station, Knox Church and the Otago University clocktower building.[5] If you look closely at this kind of stone, you will see the tiny tubes or branches of ancient bryozoans.

It's hard to imagine the amount of time it takes for animals smaller than 1mm to make enough limestone for a whole city. About 35 million years ago, many kinds of bryozoans were thriving near a warm volcano – Oamaru stone is their legacy.

Enthusiasm Inspires Art

As part of the Art + Earth project, I connected with artist Kate Steeds and we talked about bryozoans. I showed her photo after photo, enthused about various publications, called her up to mention some other wonderful thing about my favourite bugs. And she responded! Her interest in natural history informed her art, and the art reflects the inspiration of the science.

The folding book she has made illustrates what makes bryozoans fascinating – and allows the reader to find it for herself. The joy of discovery and enthusiasm I get from science comes through in the experience of exploring the panels and folds of the book.

Figure 5. Scientific discovery in action. Left: Abby Smith examining limestone at a beach.
Right: Students examining the bryozoan book at the exhibition.

SMALL DREAMS OF GRANDEUR

Katherine Steeds

Figure 6. Katherine Steeds, *Small Dreams of Grandeur*, 2020, accordion-structure book, cotton paper, collage, mixed media.

The Small World

My usual focus is on the micro view and the details of the natural world. I am fascinated by fungi and lichen, flower and leaf. I have spent thousands of hours observing and photographing insects and other invertebrates all over the world. I am equally interested in their categorisation into species as I am in their forms, functions and behaviour. At times it has almost become an obsession. Recently, my imagination has been sparked by the knowledge I have gained in my partnership with Abby.

Learning a little about bryozoans has reminded me that the extraordinary complexity of a natural environment under the sea can exceed that of an ecologically rich land environment.

My resources include science graphics like graphs and maps, equipment catalogue illustrations, instruction manuals, diagrams, electron micrographs and photographs drawn from many diverse sources. In my work, I frequently like to use these kinds of image fragments as a code for my straddle stance between science and art. I am caught between my love for rational academic research of tiny elements of the natural world, on the one hand, and my drive to intuitively express the joy of my findings visually, on the other.

In this way, through a collation of drawings I have explored some of the richness of bryozoa species and their visual complexity.

However, the book I have created also explores the role of humans, their exploration and study of bryozoa, and their utilisation of their fossilised remains. The profusion and overlapping of imagery in the book points to the fascination and complexity of such an interaction. I have included references to discovery, magnification processes, identification, mapping, building, stone carving and stonemasonry.

Figure 7. Field work in the bush.

I have decontextualised, then re-utilised, these visual tools, primarily for their compositional qualities – for example, their shape, colour and edge, but also with consideration for their original relevance or meaning.

Here is a series of composite and overlapping drawings, complex clonal compositions, incorporating layers of meaning and echoing the compound origins of the soft, creamy blocks of Oamaru stone. In making foreground and background ambiguous, I have suggested processes in the past that are yet ongoing – in spaces and gaps of information and relationships so far unknown.

A traditional book format echoes the customary presentation of scientific theories and discoveries, while a slip-cased accordion format allows viewers to choose where to enter the book and to influence their personal experience of participation through an unfolding, non-sequential disclosure – visually picking their way through a variety of bryozoan forms, many with intriguing appearances suggestive of more familiar objects.

In the work *Small Dreams of Grandeur*, Abby and I share our fascination with bryozoans. I have drawn on my thoughts about the paradoxical nature of inhabited, human-scale spaces created from stone which are the fossil remains of tiny structures created and inhabited by minute marine animals. The aim is to expand a common view of the Earth materials we sometimes fashion into buildings and decorative structures.

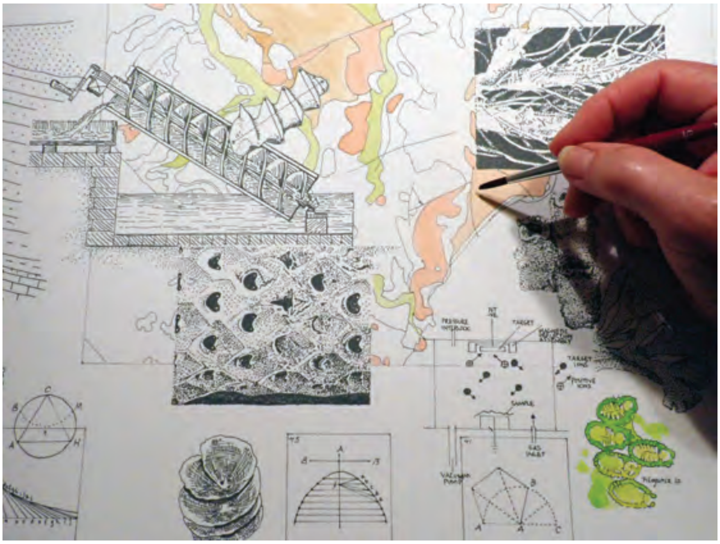

Figure 8. Work in progress.

Solution to calcium, calcium to home, home to fossil, fossil to stone, stone to habitation.

Kate Steeds, Tauranga April 2021

Professor Abby Smith, (ORCID ID: https://orcid.org/000-0001-6468-9124) Department of Marine Science, University of Otago, Dunedin, New Zealand. Abby Smith comes from New England, where early experiences wading and poking around in tidepools sent her down a marine track right from the beginning. She double-majored in Biology and Geology at Colby College, Waterville, Maine, spending a semester at the Bermuda Biological Station, where she developed a fondness for marine carbonates. She studied for a Master's degree in the joint programme at Woods Hole and MIT. While she was there she made friends with some kiwis, one of whom she married. Later, they moved to Hamilton New Zealand, where Abby completed her DPhil at Waikato in 1991, just in time to shift to Dunedin (in southern NZ) so her husband could take up a lectureship in Zoology at the University of Otago. She has lectured and researched in the Department of Marine Science at the University of Otago since it was a Department (in 1992), serving a 4-year stint as Head of Department 2013-2017. Alongside her work at the University, she was appointed to a ministerial advisory committee on Oceans Policy and chaired the Otago Conservation Board for several years, as well as having served as the Treasurer of the International Bryozoology Association for more than two decades. She was the inaugural council chair of the New Zealand Ocean Acidification Community, and has been awarded the Miriam Dell award by the NZ Association of Women in Science. She likes to stay busy, and never lets her scientific career get in the way of her other hobbies: hanging out with her two sons, knitting, making jam, and enjoying cricket.

Tauranga-based artist **Katherine Steeds** works painstakingly in a variety of media, focussing on details of the natural world especially that of plant, bird and insect. She bases her work on careful research and observation during travels in New Zealand and further afield, as well as from museum collections all around the world. She has a science degree and postgraduate diploma in art and design. Becoming familiar with individual species has given her a great appreciation and sense of the special value of the teeming and astonishing variety of species on Earth, and she endeavours to share this view with others through her works.

1 MJ Kennish, *Practical Handbook of Marine Science* (Boca Raton, FL: CRC Press, 2020).

2 J Emsley, *An A-Z Guide to the Elements: Nature's Building Blocks*, new ed. (Oxford, UK: Oxford University Press, 2011).

3 See, however, DP Gordon and S Mills, *Bountiful Bryozoans: A Guide to the Bryozoans of New Zealand*, https://niwa.co.nz/coasts-and-oceans/marine-identification-guides-and-fact-sheets/Bryozoans.

4 DP Gordon, "Living Lace," *New Zealand Geographic*, 61 (2003), 80-95.

5 BW Hayward, *Granite and Marble: A Guide to Building Stones in New Zealand* (Lower Hutt, NZ: Geological Society of New Zealand, 1987).

https://doi.org/10.34074/scop.1022027

COSY DELL – ROCKY SHORE – INLAND SEA

Scientists: Daphne Lee and Zoe Henderson
Artist: Vivien Dwyer

COSY DELL

Daphne Lee and Zoe Henderson

Cosy Dell seems an odd name for one of New Zealand's most intriguing fossil sites. Near Waimumu in Southland, it pays tribute to the name of the farm whose owners unearthed a fossil treasure trove in a small lime quarry. Since its discovery in 2009, they have made it possible for hundreds of scientists and students to study an amazing Oligocene rocky shore ecosystem far from the present coastline.

Figure 1. Fossil collectors at Cosy Dell,
with the digger that first uncovered the fossil treasure trove in 2009.

At Cosy Dell, some 25 million years ago, subtropical seas lapped up against Jurassic-age basement rocks full of fossil seed ferns. The rocky boulders and the myriads of animals that grew on and around them were preserved by layers of sand and silt and buried beneath swamps that became the Gore Lignite Measures. Cosy Dell has yielded thousands of invertebrate fossils, many preserved in very hard, calcite-cemented concretions.

Molluscs, many with aragonitic shells and colour patterns preserved, are extremely diverse. They include chitons, 90 bivalves and 250 gastropods. Bivalves include oysters encrusting rocks and thick-shelled scallops.

Figure 2. Boulder with oysters in life position and huge scallop shells, with a geology hammer for scale.

Figure 3. Tiny pāua, about 3 mm across, and giant turret shell in a concretion.

Gastropods include pāua and giant turret shells.

In addition, there are intertidal and subtidal barnacles, 120 species of microscopic ostracods, brachiopods, echinoids and waterworn reef-corals.

The rich vertebrate fauna of thousands of otoliths (earbones) at Cosy Dell shows that the shallow, warm Chatton seas swarmed with fish, including sharks and rays. Large, middle-sized and small penguins nested on the shores. Drift seeds of a tropical legume, seagrass limpets, mangrove snails, petrified logs and the pollen flora testify to a diverse subtropical coastal rainforest with nearby mangroves and seagrass meadows.

Figure 4. Reef-coral from the ancient subtropical sea.

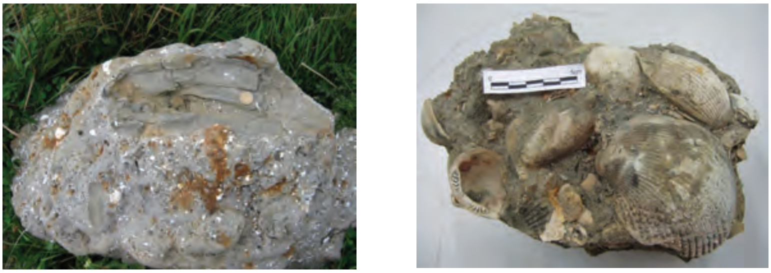

Figure 5. Cosy Dell concretions with petrified wood and shells.

COSY DELL

Vivien Dwyer

My first experience of Cosy Dell was as part of a Rock and Mineral Club trip looking for shells, corals and other things of interest at the site of the University of Otago's dig. We knew that anything of interest to them would become part of their collection. There was a lot of fascinating stuff including all of the above, along with some exploration of an old coal mine which is also in the area. I took this as my starting point, taking sketches and photos, and then tried to imagine what the place had looked like when all these fossils were alive.

I chose the weaving loom as my workplace and, using a variety of threads, set out to create the feel of the place – not forgetting a small representation of the coal deposit. I also added some of the tusk shells from the site (although most of what I collected was either too small or overly fragile). I fashioned the weaving as a number of layers showing the stratification that occurs as time goes by.

Figure 6. (detail).

Figure 7. Vivien Dwyer, *Cosy Dell*, woven tapestry, embellished with small fossils from site dig, 600mm x 970mm.

Daphne Lee is an Honorary Associate Professor in the Department of Geology at the University of Otago, Dunedin. Her research interests encompass Cenozoic paleobotany and paleoclimate, Cenozoic invertebrate paleontology, Brachiopoda and Cenozoic stratigraphy.

Zoe Henderson is a Research Assistant in the Department of Geology at the University of Otago, Dunedin.

Vivien Dwyer is a graduate from the Otago Polytechnic where she completed her MVA. She has been an artist for most of her life and returned to Art School after her children grew up and became independent. She works in textile art with a special focus on printmaking and tapestry weaving.

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Art+Science Project Report: Part 5

A PETRIFIED SAMPLER: FOREST TIMELINES CAUGHT IN STONE

Scientist: Mathew Vanner
Artist: Pam McKinlay

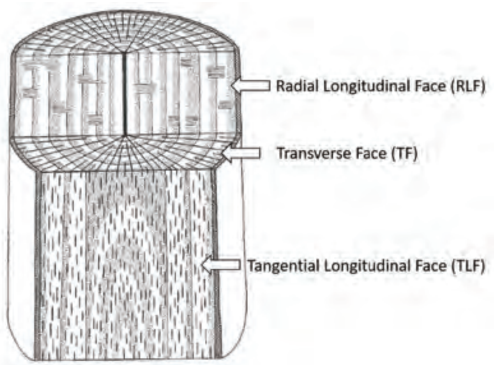
FOSSIL WOOD OF THE SOUTHERN SOUTH ISLAND

Mathew Vanner

Ancient forests covered much of New Zealand's landscape. These persisted from the time of Gondwana into the modern era. On occasion, the trees forming these forests were buried, either by ash or within an anoxic bog, which protected them from decay, as the first step of fossilisation. Exposure to groundwater with high amounts of dissolved silica, calcite or other minerals was the second step. Over millions of years, this fluid flowed through the dead trunks, replacing the organic tissue with these dissolved minerals, turning them to stone.

Eventually, after millions of years, they have been brought back to the surface. Though much of the fossil wood is found within coal seams, some samples were collected from marine sediments, river gravels, silcrete or breccia.

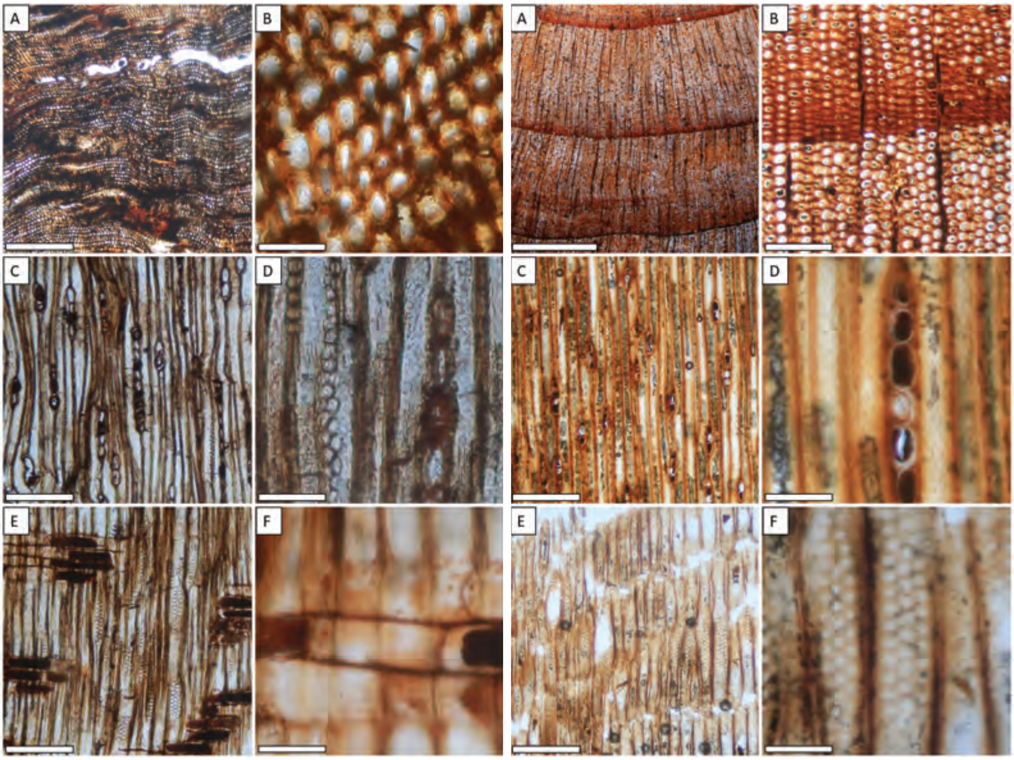
Figure 1. A rooted stump at Mataura Coal Mine that looks much like a modern stump. Hand lens for scale. Photograph: Mathew Vanner.[1]



Figures 2. Block model of a trunk showing the three orientations used in wood anatomy. Adapted from Wilson and White, *The Anatomy of Wood*, (1986: Figure 2).[2]

Once exposed, it is possible to study these ancient stone trees in order to discover which modern family or genera they were most closely related to. This is done by taking sections at different orientations – transverse, tangential and radial – which give three different views of the fossil cellular structure. These sections are carefully ground until they are less than a hair's width across. The structures revealed are compared to those of modern trees for identification. The identification of wood, both living and fossil, is based on the recognition of cellular features within the wood. It is easy to determine whether a sample is a gymnosperm or an angiosperm.[3]

In the South Island, there are many sites that yield fossil wood of different ages. It is possible to find a nearly complete record of wood from the Jurassic (200 mya) to the Quaternary (almost modern), but we find breaks in the continuity of certain genera. *Araucarioxylon*, ancient kauri, has been present in New Zealand for the entirety of that record. *Nothofagoxylon*, precursor of southern beech, has fossilised wood of Miocene age and is still present today. *Casuarinoxylon*- and Myrtaceae-like wood are also present in the Miocene, but died out before the end of the Pliocene.



Figures 3 & 4. The cellular structure of these specimens is gymnospermous, most likely Araucariaceae.[4]
The boundary between the previous year's latewood and the next year's early wood may be indistinct or distinct.
The width of a boundary can give information about the climate in which a tree grows – the wider it is,
the better growing conditions the tree lived in.

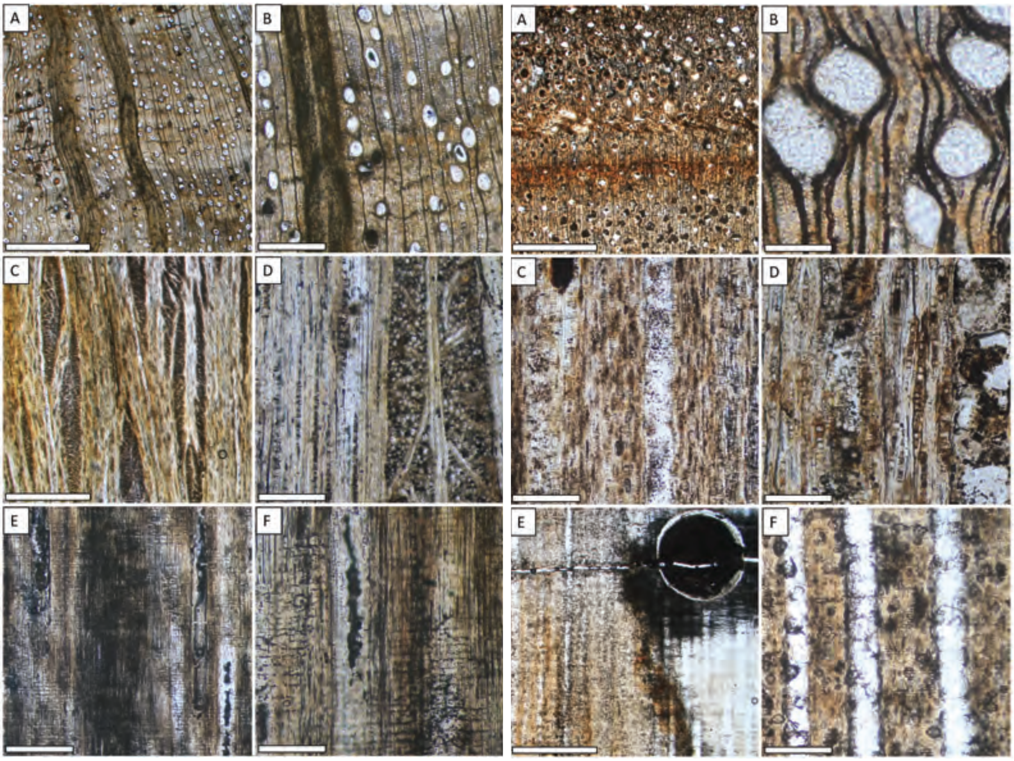


Figure 5. Casuarinaceae (left); Myrtaceae (right). The abundance of Casuarinaceae and non-New Zealand native Myrtaceae (e.g., *Eucalyptus*) in the samples was somewhat surprising, as was the low number of well-known New Zealand native genera, such as *Nothofagus*, given the dominance of southern beech pollen in both the fossil record and modern forests (Bill Lee, pers. comm.). *Nothofagus* wood readily decays, which may account for this.

A PETRIFIED SAMPLER

Pam McKinlay

Artists make art out-of-hours in unusual spaces, and this was no more true than during the Covid-19 lockdown of 2020, when I spent a couple of hundred hours on a free-weaving response to the petrified wood samples from Mathew Vanner's research. I designed a weaving sampler using a series of experimental lifts, weft manipulation and tapestry techniques to interpret his microscope slides. The title of my work reflects both the scientific methodology involved in preparing fine slivers of petrified rock samples for microscopic examination and the weaving of short experimental blocks to depict the visual material in the slides.

Figure 6. Weaving in progress. With reference to Mathew's sample slides, this weaving sampler records (left to right): Araucariaceae (New Vale Mine Southland), Casurinaceae (Landslip Hill, Southland) (she-oak) and Myrtaceae – possibly *Eucalyptus*.

"Geologists take it for granted that rock equals time … I don't know of another experience that we all have in our daily lives where a solid substance represents time."

Peter Brannen[5]

Petrified wood is rock that reveals something particular to the trees from the time and conditions when they were living. Somewhat miraculously, the textures and patterns of the live individual are captured in the fossil wood, and can be seen millennia later in the fossilised remains. Across the different species, the cumulative fragments reveal morphological similarities and distinctive characteristics at the cellular level.

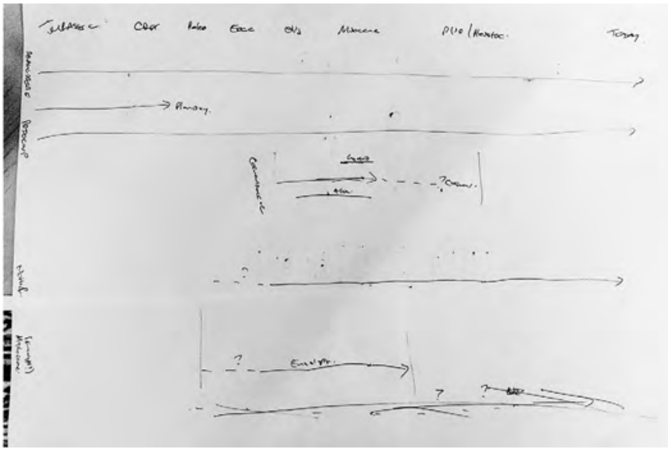


Figure 7.
When I first met Mathew, we discussed the fossil wood record in the South Island, which he sketched as a timeline.
Across the top:
Jurassic, Cretaceous, Palaeocene, Eocene, Oligocene, Miocene, Pliocene/Pleistocene (amalgamated, as much of the wood from these eras is difficult to date accurately), Today.
Along the side:
Araucariaceae, Podocarpaceae, Casuarinaceae, *Nothofagus* and Myrtacea (*Eucalyptus*).

Figure 8. Colour palette derived from microscopic slides of fossil wood samples. Mathew's schema gave me the rationale and bare bones for the warp. The next step was to take the colours from the slides for the warp timeline, and the final stage was to create weft infill that would reflect the patterns in the slides.

To augment the woven panel, I also collected windfall from local monkey puzzle trees (from the Araucariaceae family), which I covered in paper clay and fired. Clay comes from areas where streams or rivers once flowed; it is made from broken-down mountains, minerals, plant life and animals from long ago. In a poetic gesture, the firing process accelerated the fossilisation process and (re)turned my windfall from living tree to rock.

In my limited time working with Mathew's research, he introduced me to the lineage of four different families that we are familiar with in our everyday lives. However, certain species within those families are under threat and face extinction events, as others have done in the past. This gave pause for thought on the fragility of the lineages I was weaving.

As we view the stops and starts in the artwork, we might reflect on the continuity of the remaining untampered line in the weaving, the Araucariaceae lineage, and ponder its future and conservation status in the new century: threatened by kauri die-back (New Zealand); facing the constant double threat of extinction and wildfire for the remaining stand of Wollemi pine (Australia); and appearing on the endangered list and CITES Appendix for monkey puzzle trees (Chile, Argentina).

Figure 9. Pam McKinlay, *Sampler: forest timelines caught in stone*, 2020-21, tapestry, single-ply and fine wool, wool silk, 510 x 2500 mm. Hand-woven on a 12-shaft table loom with a double warp beam, with fired clay forms representing *Araucaria araucana*. Transparencies by Mathew Vanner.
Reading from top to bottom, the Araucariaceae, Casurinaceae and Myrtaceae families traverse the Jurassic to Quaternary periods in a linear paleo-botanical timeline.

Mathew Vanner is a PhD candidate at the University of Otago. He has been interested in rocks since he was very young, collecting rocks until his pockets were full to bursting. Collecting any rock turned into a love of fossil wood after meeting a lapidarist in Southland, developing into a half-decade-long quest to identify fossil wood after meeting geologist Daphne Lee.

Pam McKinlay (ORCID ID 0000-0002-1731-6437) has a background in applied science and the history of art at the University of Otago. She collaborates with other artists in community outreach and art+science education projects on the themes of climate change, sustainability and biodiversity.

1 Mathew Vanner, "Cenozoic Fossil Wood of the Southern South Island, New Zealand," (MSc thesis, University of Otago, 2017).

2 K Wilson K and DJB White. *The Anatomy of Wood: its Diversity and Variability*, (London: Sobart and Son Ltd. 1986), Figure 2.

3 Ibid., p. 22. For gymnosperms, the comparison data for the New Zealand native species was taken from BA Meylan and BG Butterfield, *The structure of New Zealand woods. New Zealand Department of Scientific and Industrial Research*, 1978, Wellington. Data for other species was extracted from several publications, including RT Patton, "Anatomy of Australian Coniferous Timbers", *Proceedings of the Royal Society of Victoria*, 1927, 6(1): 1–16 and P Greguss, *Identification of Living Gymnosperms on the Basis of Xylotomy*, Akadémiai Kiadó Budapest, 1955 and P Greguss, *Xylotomy of the Living Conifers*, Akadémiai Kiadó Budapest, 1972. For angiosperms, the features noted are listed in the International Association of Wood Anatomists softwood catalogue (IAWA Committee, 1989) – Inside Wood website at https://insidewood.lib.ncsu.edu/search?1 .

4 Vanner, "Cenozoic Fossil Wood." See discussion at 8.3.1: Araucariaceae, families and higher taxa including non-native *Araucaria* (Wollemi pine) a remnant population of which survives perilously in New South Wales, Australia.

5 Peter Brannen, "Glimpses of a Mass Extinction in Modern-day Western New York," in *The Best American Science and Nature Writing* 2019, ed. Sy Montgomery (Boston: Houghton Mifflin Harcourt, 2019), 26.

https://doi.org/10.34074/scop.1022029

WOOL WEAVES AND ROCK FABRICS: AN ART+SCIENCE PROJECT PARTNERSHIP BETWEEN WEAVING AND GEOLOGY

Scientist: Adam P Martin
Artist: Christine Keller

THE MAKING OF 'OTAGO SCHIST'

Common terminology in geology: fabric, texture, structure, ribbon, parameter, folding, stretching

Common terminology in weaving: fabric, texture, structure, ribbon, parameter, folding, stretching

The iconic Central Otago landscape of tors (pillars of rock; Figure 1) are made of schist.[1] Schist is a type of rock that was deposited as mud- or sand-sized fragments in the ocean some 250 million years ago.[2] The fragments were buried and heated (metamorphosed) and squashed and stretched (deformed) on the long journey from ocean floor to onshore New Zealand.[3] This history is recorded in the rocks, as can be partly seen when looking at them under the microscope (Figure 2).

Figure 1. A photograph of the Otago Schist, taken near in the Maniototo, Central Otago, New Zealand. The tors in the foreground are 3-4 metres tall and the Rock and Pillar Range can be seen in the far distance.

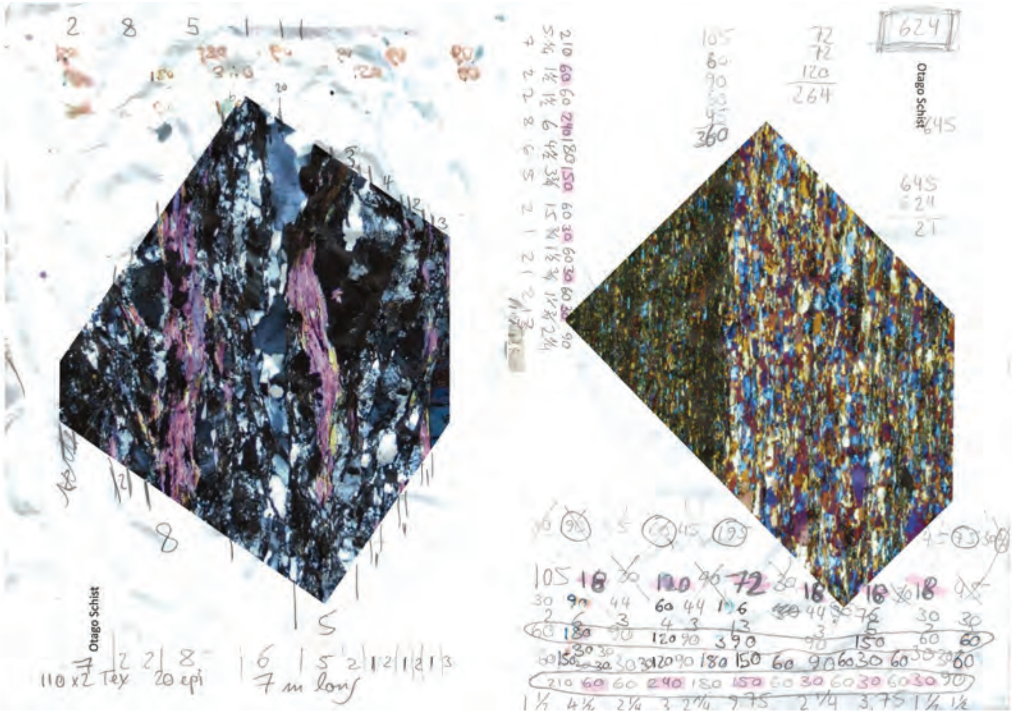


Figure 2. Otago Schist rock under the microscope. Each image represents a specimen 4 mm in width under the microscope, but has been enlarged and printed on A4 paper. The different colours represent individual minerals. The images show the effect of polarised light passing through minerals of differing composition and structure. Both samples are rock specimens from the most highly deformed parts of Otago. The handwritten notes were added by Christine Keller during the making of the work.

Here (Figure 2), schist rock has been polished to exactly 0.03 mm thick, which is so thin that light can shine through. Scientists use polarised light which highlights *ribbons* of the mineral mica as bright pinks, purples and yellows. This is juxtaposed against the greys, blues, blacks and whites of the minerals feldspar and quartz;[4] (Figure 2). This layering forms from different mineral proportions, reflecting variations in the original sediment, being sand-sized or mud-sized.[5] Other minerals present in the rock include epidote, chlorite, amphibole and stilpnomelane, with accessory amounts of titanite, garnet, zircon and pyrite.[6]

This specimen is from the most strongly metamorphosed and deformed areas of the Otago Schist, such as can be seen around the Maniototo in Otago (Figure 1). This represents the deepest parts of the schist rock now exposed at the surface in New Zealand through uplift and erosion.[7] Even more highly metamorphosed and deformed rocks are likely still buried beneath Otago.[8]

The layering of minerals defines a dominant *fabric*. The fabric records one of the important events that deformed this schist rock as it was lifted from deep in the Earth towards the surface.[9] The art of weaving beautifully represents the colours, layers and fabrics seen in schist rock from Otago.

INSPIRATION

Christine Keller recalls:

> "… my father from my childhood who, as a teacher, spent a huge amount of time researching mineral and metal crystal structures. He wanted to be able to visualise the theory and to understand what the science told him. This was at a pre-internet time and without access to my go-to 'auntie google.' He turned to experiments instead. He searched for the right orb to represent carbon and other atoms, trying out ping-pong and swimming pool cover balls, and finally settling on small nylon balls. These experiments meant our house was full of spheres glued together to form conglomerates or crystal structures. Other memorable experiments included blowing dishwashing liquid through a thin hose onto the surface of the bathtub to understand the organisation of grain boundaries between different crystals. Life became even more exciting when my father gained access to an electron microscope and we could watch crystals grow and experiment with polarised light. With this background, I was primed to work with a geologist and, at the introductory sessions for the 2019 project, I found my match in Dr Adam Martin of GNS Science, who showed colourful pictures of rocks under the microscope. It was the Otago Schist rock that caught my eye."

Adam Martin writes:

> "I grew up surrounded by people interested in rocks and the world around them, and also grew up visiting art galleries and art exhibitions. During my undergraduate studies, I became fascinated with the practice of studying rocks under the microscope (petrology) and the world of spectacular colours and patterns this reveals. So I was excited and motivated when the opportunity arose to work with Christine to translate this into an art piece. I felt the colour and tactile nature of weaving was especially well suited to Otago Schist rocks as they look under the microscope."

PROCESS

A bonus of the collaboration between artist and scientist was a field trip organised by Adam for Christine and her husband. The three of us visited the Maniototo district to see the rocks and the landscape that inspired the work (Figure 1).

Christine recalls:

> "Adam reminded me that the rock was from the Maniototo district in Otago and asked me if I had materials from that area – which I did. I used wool from sheep raised at Armidale in the Maniototo and spun in the now defunct Milton Mill. This local yarn I used to represent the mineral mica (bright colours; Figure 2) in the work. The other material used was a superfine merino yarn to represent the quartz and feldspar minerals in the work. This yarn originates either from Australia or New Zealand, is spun in Italy, purchased in Germany and brought back to New Zealand, and so has quite a carbon footprint 'yarn' to tell.
>
> I prepared various warps that were dyed for different colour effects, based on the photographs taken under polarised light. The warps were 10m long. The loom used for this project was a 16-shaft compu-dobby with two warp beams, which gives one a choice to weave more than one layer under different warp tensions. The loom was warped with one predominantly anthracite in colour on one beam, and the other one dyed in greys and purples on the second beam.
>
> During the weaving process, the serendipity with which a rock is pulled, stretched and cooked during its history inspired me. The exact outcome for a rock is not predetermined, even though the parameters of the process are somewhat clear, and I wanted to adopt a similar approach in my work. Weaving is

a complex technique, where the weaver typically plans where and how the two thread systems – warp and weft – intersect. I had a general idea in mind for the weaving (Figure 3), but not a strict threading or lift plan. For this work I took a more free-form approach. While maintaining the integrity of the fabric with a certain number of threads to hold the piece together, I could let the other threads float freely.

All was going very well, but then lockdown hit.

It was not until January 2021 that I restarted the weaving. I recalled the weaving parameters I had set, but not the exact threading. So, I wove intuitively, always responding to the last little bit, evolving the work with time."

Figure 3. Fabric inspirations – some fabric samples I chose in order to roughly estimate a technique which I thought suitable for creating a response to the rock type and layered geological processes under consideration.

OUTCOME

Figure 4. The three original panels to come out of the collaboration.
Adam Martin holds the first, felted panel at the first viewing in Dunedin's LoomRoom.

Christine recalls:

"Three panels emerged (Figure 4). The first one was felted, as is my normal process. However, I was surprised when panels two and three spoke to me, asking not to be felted (Figure 4). Panel two is a single-layer fabric with lots of floating threads. The third panel is a double weave (Figure 5), which I truly enjoyed as a new piece of work, the likes [of which] I have never done before. I was thinking of the women weavers at the Bauhaus and, training-wise, one could call me a grandchild of the Bauhaus school. This third panel has inspired me to want to push my work further than I have been doing for a long time. Recently, I have dedicated my time to set up and run a weaving studio (Figure 4) that works for many as a community workshop and has been very rewarding. But now I feel it is also time I give myself more space to research and create my own favourite weaving works. I am so thankful that Adam Martin has stayed alongside my work through all the steps of the process."

Figure 5. Installation image of *Otago Schist* in Dunedin May 2021.

German-born, New Zealand-based artist **Christine Keller** holds an MFA from Concordia University (2004) in Montreal, Canada, and a Masters equivalent from Gesamthochschule Uni Kassel (1994), Germany. Christine has exhibited her award-winning work nationally and internationally since 1987. She was the academic leader of the Textile Section of Dunedin School of Art at Otago Polytechnic from 2005 to 2010. In late 2012 she founded the Dunedin-based weaving studio Weaving on Hillingdon, and in 2015 the community space known as Dunedin's LoomRoom. This is the fourth Art+Science project she has joined. As an immigrant to New Zealand, Christine took New Zealand Citizenship in 2016.

Adam Martin (ORCID ID: https://orcid.org/0000-0002-4676-8344) is a senior scientist working for GNS Science. As a geologist, his main interest is understanding how chemicals and minerals influence how the world works and how they interact with humans. Adam specialises in volcanoes, the deep Earth, Antarctica, soils and the Otago Schist. He studied his undergraduate degree at Monash University, Australia, before undertaking his doctorate at Otago University, New Zealand. This was followed by a three-year post-doc with the Natural Environment Research Council, UK, and a European Union Marie Curie Fellowship at the Bayerisches Geoinstitut in Germany. His research has been undertaken on every continent.

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