THE CMLC NEWS

February 2026

- Auctions & Auctions
- Tessa's Recap of 2025
- The CMLC Acquires New Stones
- 'The Fossil Boiz' Hit The Jackpot!
- Searching for New Club Dig sites

Photo of Glenafric beach by Andrew Fear

General Meeting (7:30pm): 12th February

Annual General Meeting (7.30pm): 11th June 2026

Committee Meeting (7pm): 19th February

Micro Mineral Meeting (7pm): Tuesday evenings

Workshop (6.30/7:00pm – 9:00pm): Every Tuesday, Friday

CMLC Clubroom

110 Waltham Road, Waltham,

Christchurch

A Quick Word From the Bulletin Editor

A happy new year to all and a big thank you to everybody who has given me content to use in the newsletters during 2025. I also appreciate the lovely feedback that people have given me. I wanted to kick start this New Year's edition with a new look, I hope you like it. I am still tinkering and learning how to incorporate new features, so expect improvements and new features as the months go on!

- Tyler McBeth

Stew Point Agates for the Club Cabinets

Agate enthusiast and lifetime member, Malcolm Luxton has generously allowed the club to purchase 10 dashing Stew Point agates for the club cabinets from his collection last November. These agates are quite striking, so be sure to check them out in the cabinets when you get a chance! Our club is still on the lookout for a display of Nimmos swamp agates from Otago, if anybody wishes to sell, donate or lend.

13cm of top quality Stew Point agate, designated for the display cabinets

From the Auction House

It's been a good year for auctions in 2025. Lots of amazing rocks sold. We had Craig McGregors material which was very good material. Jenny Grundy had whole lot of stunning crystals, Julian had some good agates plus there was a lot of other great stuff too numerous to mention. If you want more great material to add to your collection, be sure to attend our club meetings in 2026!

- John Taylor

February Auction

This month, we start out strong with a resurgence of Craig McGregors old material at the February general meeting. The type of material being sold is currently unknown, but at a guess, it would possibly consist of Australian and New Zealand agates and petrified wood, along with other odds and sods from various places around the globe.

Welcome New Members

Welcome to Bonnie & Blake Moore-Boyle, Sandra McLintock, Will Fisher, Rod Deverson and Ian & Shelley Gibson.

If anybody knows Maria Lee, please contact cmlclub@chch.planet.org.nz We don't have her email address.

Club auctioneer John Taylor, holding a couple of his favourite agates

A Life Remembered

As many will already be aware, the CMLC lost one of its dearest and most valuable club members on the 6th of January. Malcolm Luxton was an integral part of the CMLC, first joining over 40 years ago with a burning passion and intrigue towards all things agates. Malcolm's hunger towards pretty stones led him to become the author of the book *'Agates of New Zealand'*, which is has been sold all over the world, showcasing a lifetime of Malcolm's pulchritudinous rocks from his collection. It is no wonder why this book is regarded as the agate bible amongst kiwi rock-hounds!

It must also be mentioned that Mr Luxton had served as the longest running club president in the CMLC history. Seven years of dedication towards the role kept our club running smoothly. So much so, that nobody wanted him to relinquish the title!

However, despite Malcolm's numerous accolades, Malcolm's selfless nature shone brightest most of all. His bonafide sincerity and willingness to assist and dedicate his time and effort for strangers, and his overall cheerful demeanor will be greatly missed by all who knew him.

- Tyler McBeth

Scouting for Dig Sites

It's no secret that our club is rather limited for options when it comes to agate based field trips. This is due to most notable locations that were previously considered worthy of digging, are now off limits due to lack of access. Fortunately, with access to Matariki forestry blocks, we have begun work, hoping to find new areas, rich enough in agate worthy of future field trips for the rest of the CMLC. Currently several committee members have undertaken one such trip, which unfortunately proved uneventful due to the dense broom and gorse that halted our searches. Despite this failure, we are already planning out second trip, hoping to bring more variety to the club in the future.

A couple of dedicated blokes

Presidents Report
January 2026

—— Tessa Mitchell-Anyon

As we settle into 2026, it is good to reflect on the past year to remember some of the highlights and achievements our club has had. In no particular order, here are a few noteworthy events that stick out to me:

I couldn't start anywhere other than being voted in as Club President at the AGM in June. Taking over from our former President, Malcolm, was a daunting prospect. Having done an exceptional job running the club over the past seven years, he left some big shoes to fill. I feel confident I am the best candidate for the job, and it seems enough of you agreed! Now I get to stand up at the front and lecture you all about remembering to sign the book at the door when you come in!
Though Malcolm is sadly no longer with us, he will be fondly remembered for all the hard work and funny anecdotes he shared with us during his 40 years in the club.

The workshop has been doing extraordinarily well, with plenty of keen lapidarist keeping John, Chris, and Kamen busy on Tuesday nights. There has been so much interest we started up a second night of the week on Fridays to keep up with the eager demand, thank you Chris for running this!
There are plenty of exciting new things coming up in 2026 in the workshop, so keep an eye out for some much needed new bench space and air circulation systems.

We have had plenty of interesting field trips over the past year. With greater access to Whitecliffs again after work to make the dig site safer was completed, we have had a number of trips here with many members finding some impressive nodules. We have also had trips focusing on geology, such as visiting the University of Canterbury and exploring their rock collection as well as getting an inside look at creating thin sections of rock to view under the microscope for mineral analysis.
Moving into 2026 there will hopefully be plenty of cool rocks found by members to display on the bring and brag table at monthly meetings, and there are plans to hopefully expand our options for dig sites with some exploration underway.

A special thanks to Anna and John Baker for their work on our Club Show and social media presence this year. We now have 2800 followers on our Facebook page which wouldn't be possible without the time, energy, and creativity Anna has put into this!
The Club Show was also a great success with lots of positive feedback from the community and from sellers at the show. We also had a couple of other market style events that also went very well. Hopefully we see more thriving shows and events in 2026. I know I can't wait to eat another one of those delicious cinnamon scrolls from Haydene in the kitchen!

Looking forward to seeing you all again soon, hopefully with a pocket full of rocks and a conversation full of laughs.

Your Pres,
Tessa

Meet The CMLC

Lucas Goodgame

When and why did you join the CMLC?

Fabian Ong was showing up to work each day with different and interesting rocks and kept talking about the lapidary club, so I showed up

What do you like most about our club?

Working with my hands is always fun. I also enjoyed the day out to Otago. We grabbed some of the rhodonite, which was really fun. It is also good to be around like minded people.

What is your favourite rock/mineral?

Probably aotea stone.

What is your favourite memory in this hobby or community?

Driving in the car with Pete Vallance to the farm for rhodonite, that was pretty fun.

Do you have any hobbies outside of lapidary or rockhounding?

I do rock-climbing, and paint acrylics and miniatures

High Peaks Forest Field Trip

When

14th, 21st February (Saturdays)

Where/Contact

Contact John Taylor (0272027523) if you wish to attend. The meeting place will be on the corner of Washpen road and Darts road at 8:30am
https://maps.app.goo.gl/XKmXbJcr1G6PQGAn8

What to Expect

Bush bashing through some thick Broom, Gorse and Pine. Digging is the only viable way of finding agates, agatised wood and jaspers here. The soil will likely be pretty wet.

Hazards

Uneven ground and dense thickets of Gorse and Broom make an ideal tripping and stabby hazard. It can be easy to get lost in this area as well, so staying close to the group is advised.

Fitness requirements

Digging in thick muddy soil can be hard work, but you can go at your own pace and still find material

What to bring

Please bring your own food and water. Insect repellent may help against Mosquitos. Appropriate clothing if rain is forecasted. A high vis vest is mandatory. **(If you do not have one, you will not be allowed to attend)** A shovel, a pickaxe and a smile.

Whitecliffs Field trip

When

15th, 22nd February (Sundays)

Where/Contact

Contact Julian Twiss (0274361463) if you wish to attend. The meeting place will be at the Glentunnel Community centre at 8:30am (By the toilets)
https://maps.app.goo.gl/W8djzexoPjxpWYE16

What to Expect

Due to heavy rain, you may expect thick wet clay and the need to bail out water from where you wish to dig.

Hazards

Undercutting banks whilst digging may cause large amounts of rock and clay to collapse upon yourself and others. The clay at Whitecliffs can be slippery when wet. There are also people who will be swinging pickaxes and shovels full of sediment around, so be sure to give people their space.

Fitness Requirements

Same as High Peaks, except depending on certified vehicles present, you may need to walk up a track to reach the dig site.

What to Bring

Please bring your own food and water. Appropriate clothing if rain is forecasted. A high vis vest is mandatory. **(If you do not have one, you will not be allowed to attend)** A shovel, a pickaxe, a bucket for your finds, and a scrubbing brush for identifying agates from rhyolite (that stuff can fool the best of us)

One of Those Rare Days

I hadn’t visited Glenafric beach for several months. As somebody who hasn’t prepared a fossil for over a year, I can't exactly say that the long queue of fossil concretions that I’ve accumulated hasn’t become scarce. With the recent heavy rainfalls and fierce ocean swells this wet January, Kamen and Morne convinced me to tag along, and give this favourite beach of mine another solid larrup.

Accompanying Kamen was a visitor to New Zealand's shores, A Scottish chap named Christian Diprose, who is in Aotearoa for his medical degree to become a neurosurgeon. Christian is also an avid rockhound within his homeland, fossicking beaches for the best agates he can muster. It’s not just agates, though. Christian is also familiar with fossil hunting, so he was anxious to see what New Zealand had to offer.

Our troop of siltstone-seeking weirdos arrived at the car park. The weather was humid and sunny, a sharp contrast to yesterday's deluge. On the way to the beach, Kamen doubted we'd find shark teeth along the track, even after I’d informed him about when Morne had found a couple of large ones. Not five minutes later, Kamen picked up his best fossil shark tooth yet—right in the middle of the track! While we marvelled at the first find, Kamen joked to Christian, *“Just wait. Usually if I find something cool at the start of a trip, everyone else finds better stuff later on!”* We all laughed, unaware of how accurate Kamen's prediction would be.

Kamen’s amazing Shark tooth

Christian with his bird bone concretion!

At the base of the cliff, you’re always faced with a decision. Do you walk north or south? To the north, you have 800 metres of rocky beach, with moderately sized concretions, and to the south, you have a 4km stretch of mostly sand, but with some larger concretions exposed after strong swells. Fortunately, this was a no-brainer. Looking south showed many rocks that were normally covered with sand, yielding potential for great finds.

The first hour of walking passed rather uneventfully, despite the several worn-down crab fossils we'd found; nothing qualified as keepers. It wasn't until Kamen called out excitedly, *"I think Christian found bird bones!"* Sure enough, a section of thin fossil bone resembling a cross-section of coracoid from a bird was visibly immersed within a round concretion of roughly 5kg. Bird bone from this beach is very rare; the fact that Christian found a fossil like this is undoubtedly a welcome case of beginner's luck for his New Zealand stay!

Further searches down the beach yielded Morne his first interesting find of the day. A small black piece of shell in a 10kg rock. I suspected a squid beak or a piece of shell. Morne thought it could be a possible crab claw or a creature's tooth. This mystery rock eventually turned out to be a claw (propodus) part from a ghost shrimp. Soon after Morne's shrimp, Kamen found a fossilised fish skull. It seemed all was going to plan, and the finds just started rolling in from there! In one particular area, I found a beautiful fossil crab with its claws exposed. A couple of moments later, Kamen found one with claws showing, too! Within thirty seconds, Morne found a third crab with a big claw! It seemed that the fossil gods were smiling upon us, and our packs were starting to feel heavy with extravagant finds. After the crab spree concluded, I found a fossil epiphysis of a whale, which is a thin disk that connects to the vertebrae. My bag was already growing in weight, and we were several kilometres from the car, but….. It would be rude not to take it. It was only an extra 3kg of weight after all. Towards the end of the beach, a couple of agates were discovered amongst the smaller pebbles littering the yellow sands. Agates seem to be uncommon at Glenafric, but they are always a welcome treasure for the pocket.

Above - A Ghost Shrimp propodus that Morne found

Below – An extant species of Ghost Shrimp, showing the claw for comparison

Soon after turning around, Morne noticed a set of bones sticking out of the mud near the bank. A few photos were taken of the joints before being swiftly sent to Paul Scofield at the Canterbury Museum for identification. Paul recognised the bones belonging to a Sooty Shearwater, also known as Mutton bird. For those not aware, Mutton birds are a declining species of sea bird that create burrows lined with plants, and are only visited at night, where the chick awaits its supper. I can only speculate what happened to this unfortunate bird, but perhaps its burrow collapsed, hence why the bones were preserved so well.

We didn't expect many new finds on the way back to the car, being that there were four of us on the beach, but that didn't stop me noticing something that was truly remarkable *"Hey, look over there, a shark vertebra. If there is only one, you can have it Morne"*, I quipped, as the rock probably weighed 40kg and 35cm long. Finding the odd isolated shark vertebrae in these large concretions occurs relatively frequently on Glenafric beach, so I wouldn't mind leaving it behind. Morne flipped over the rock, exposing two more vertebrae on the other end. Our jaws dropped as we

Three happy fossil hunters with their crabs

knew this was something special and very rare. From what we can see, there is likely a column of articulated shark vertebrae within this 12-10 million-year-old rock! The vertebrae are 4cm wide on one side and 3cm on the other end. Calculating the size of this shark online revealed that the shark would have likely been roughly three metres in length. The vertebrae tapering on one side indicate this shark may have been a Lamniform-type shark, similar to a Great White.

Morne makes carrying 37.4kg on his shoulders look easy!

Now, to get it to the car! 3km walk on the beach, up a cliff and through the paddocks… Not too difficult, right? After all, it is only half of my body weight in siltstone! Well, I picked it up, as the rock wouldn't fit in my pack, and began awkwardly staggering with this boulder cradled between my arms along the beach. I made it roughly 20 metres before my splint on my damaged finger started slipping off, which I couldn't risk. Luckily for me, Morne is somewhat of a professional when it comes to hauling large fossil concretions off Canterbury's beaches. I cannot thank him enough for offering to carry it back for me. In return, I bought him a big box of Cokes to show my gratitude, and lugged out his large Ghost Shrimp claw concretion, which tore my pack and left marks behind on my shoulders from the straps for several days following. I'd hate to think of what the Shark vertebrae concretion would have done to me!

Fresh from the cliff! Notice the orange leg rings protruding from the rock

Once we arrived back at the base of the cliff, we dropped our bags up the bank and decided to have a break and go north, because our packs weren't heavy enough by this point! Walking north yielded us two or three more crab fossils, including an extremely fresh crab concretion that may have fallen from the cliff within the last 24 hours, and the most beautifully blue agate I've found. It was certainly not a bad finale to an unnaturally productive trip. Of course, we still needed to climb the cliff and tread 750 metres of farmland. Once we reached the car, we could breathe a sigh of relief and indulge in the satisfaction of our discoveries.

How's this for a blue agate!

- Tyler McBeth

Display Cabinet Donation

Malcolm Luxton donated this beautiful specimen to the CMLC. It is orbicular granite from Karamea, on the west coast. This 22cm polished stone will be on display in the club cabinets for the foreseeable future.

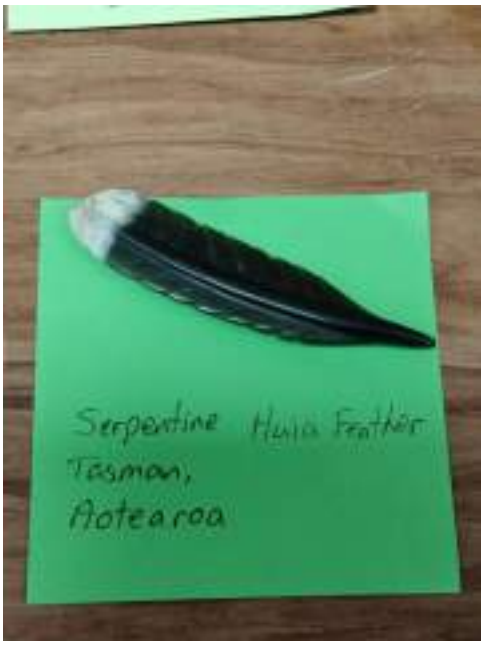
CMLC Agate Creek Trip

A potential overseas club trip around June of 2027 is on the cards to fossick in Agate Creek in Australia in search of agates. If this interests you, please contact cmlclub@chch.planet.org.nz. We are aiming for a minimum of 6 people to make this trip happen. More details will be available in the following months.

Letter From the Competition Judge

Another year, another club competition! Welcome back to our first newsletter of the year, I hope everyone has rested well, travelled around, and collected plenty.

Last year the competition table was filled to the brim with amazing specimens, and I found it rather difficult to pick out my first places. Some of my personal favourites from our November meeting included Malcolm Luxton's Agate Creek pseudomorph, Campbell Potter's Huia feather carved from serpentine, and John Taylor's beautiful petrified wood from Cave Stream, Mt Somers.



We certainly have some talented folk within our club!

In addition to our regular competition, it is tradition to start the first meeting of the year with a large "Bring N Brag" of all the amazing finds or creations from over the holiday season. I encourage you all to bring along something interesting and tell us about it! I know I'm not the only one who is excited to see what everyone has been up to.

Malcolm had good taste when it came to agates

Thanks for reading and I hope to see you at the meeting!

- Kamen Engel, Secretary and Competition Judge

READ IT AND WEEP! – John Taylor

Stunning pounamu

Monthly Competition Results for November

Ranking	Lapidary own work: Pounamu	Fossil: Fossil Wood	Mineral: Garnet	Alphabet cup: State or country starting with (E, A, T)	Agate Arena: Floater	Bring N Brag
1	Campbell Potter	Chris Thian	Don Stanley	Malcolm Luxton	Tyler McBeth	Malcolm Luxton
2	Malcolm Luxton	John Taylor	John Taylor	Campbell Potter	Chris Thian	John Taylor
3	Don Stanley	Malcolm Luxton	Errol Hitt	Robin Hall	Malcolm Luxton	Rob Lindsay
4	Robin Hall	Robin Hall	Chris Thian	Chris Thian	Robin Hall	Tessa Mitchell-Anyon
5	Chris Thian	Ava Wilson	Fabian Ong	Ron Poskitt	Ron Poskitt	Miranda Bryant
6	Lewis Hall	Rob Lindsay	Lindsay Day	Fabian Ong	John Taylor	Paul Morgan
7	Ava Wilson	Iain Fryer	Ava Wilson	Zena Wilson	Tessa Mitchell-Anyon	Jan Price
8	Zena Wilson	Lewis Hall	Zena Wilson	Ava Wilson	Lindsay Day	
9	Fabian Ong	Ron Poskitt		Lindsay Day		
10	Ron Poskitt	Zena Wilson				
11	Rosalie Clarke	Lindsay Day				
12	Lindsay Day	Rosalie Clarke				
13		Errol Hitt				

Competitions for 2025/2026:

Category	Lapidary <u>own work</u>	Fossil	Mineral	Alphabet cup: State or country *starting with* (O,L,B)	Agate arena
Feb-26	Any polished geode	Something from Otago	Olivine	O, L, B	Any Mt Somers
Mar-26	Any sphere	Something marine	Any lead mineral	Q, F	Tubes/plumes
Apr-26	Flint/Chert	Trilobite	Tourmaline	W, U	Any Otago
May-26	Carnelian	Something from Canterbury	Any form of calcite	Y, P, V	Any uncut nodule

Workshop Update

The workshop is back up and running again this year with a massive thanks to Chris Thian for putting in tons of hours over Christmas and New Years to fix up all the damage accumulated over the last year! Also, thanks to John Baker for providing some new machines and for fabricating spare parts on his handy lathe.

This year's workshop features some major upgrades… We have new benches, new machines, new non-slip floors, new plumbing, new wiring, and hopefully some new enthusiasm from all of you keen workshop goers! There's still more in the works with an extractor fan system and some more equipment being on the cards over the next few months. Hope to see you there, and don't forget to buy your workshop tutors a beer or two if you like the improvements!

Kamen Engel – Secretary.

Morne Shocks the Scientific World Yet Again!

In 1984, a large concretion containing some fish bones was retrieved from Hampden Beach in North Otago and taken to GNS where it was prepped to reveal a beautiful billfish skull. It was later featured on the back of the GNS book “Photographic Guide to New Zealand Fossils”, one of the first fossil hunting books I had purchased. I remember always looking at it, fascinated by that huge eye, never for one moment thinking I might find anything comparably myself!

An incredible billfish skull found in 1984

In 2020, I pulled in at Hampden Beach so my daughter could stretch her legs and burn off some energy at the playground at the picnic area next to the ocean. This was my first visit to the area and I noticed some interesting looking cliffs across from where the creek flowed into the ocean. It was still low tide so I thought I would have a quick look-see, as us rockhounds tend to do!

Less than ten minutes into that short exploration, something dark and textured caught my eye sitting in amongst the shingle. My first thought was petrified wood, and it certainly looked the part.

Morne with his catch of the day!

Luckily, I had my video camera with me and started filming the moment. Then I noticed something that stopped me in my tracks. There was bone texture! That was when the excitement really kicked in. At the time, I had no idea how old the rocks in the area were, and my best guess was that I’d stumbled across a dolphin skull.

I posted a photo on social media soon after, and it didn’t take long for others to weigh in. A few people recognised it straight away. It wasn’t a dolphin, but a large fish skull. More specifically, a billfish. These fish have distinctive features, including large sclerotic rings behind their eyes and rows of tiny, brush-like villiform teeth. What started as a quick playground stop turned into an unexpected fossil discovery, all thanks to a short walk and a rock that didn’t quite look right. I notified the local museums about the find and they were quite excited about it but there was no-one around with the expertise to study it further. I made sure to store it away in an air tight container with some silicon packets to keep the moisture at bay and made sure I had all the GPS coordinates stored safely.

A couple of years later, I stopped at Hampden Beach again and walked along the cliffs, keeping an eye open for any fossils. About 200m further down the beach from where I had found the large fish skull, I spotted another piece of bone. It looked very symmetrical (usually a good sign!) and I carried it back to the car. Back home in Christchurch, I compared it to the first section of skull and could not believe my eyes, they fit together! This piece even had a section of the other eye that was missing in the first section. Talk about luck!

Two sections of the same skull.

Morne makes an excellent fossil angler!

A few years later, a North Island palaeontologist, Seabourne Rust got in touch with me about the fossil billfish skull. He had studied palaeontology at Otago Uni and had already described a new species of billfish from the area. He was interested in studying the skull further and wanted to also do a study on the 1984 skull stored at GNS. I was of course super excited about this and couriered the skull to him where he could do all the measurements and comparisons. Two more palaeontologists joined the study, Rodrigo Otero from the University of Chile and Marianna Terezow from GNS (now called Earth Sciences NZ). This is when the real work started, I was given a front row seat to all the work that is involved in describing a new species: the meticulous comparisons that need to be made with all other fossils billfish, the work to place the age of the fossil using microfossils as this was a loose concretion (not in situ), the computer programs that crunched the numbers to generate a likely billfish family tree, and so so much more.

The end results of months of work was an 11 page manuscript, describing the skull I had found in two sections as a new genus and species. It was named Zealandorhynchus fordycei after the famed Otago Uni prof, Ewan Fordyce. The manuscript was submitted to a journal called Gondwana Research where it was published a few months later after a round of edits by peer reviewers.

What amazed me about the process was how much work is involved in publishing a paper, there were a huge number of edits to the document across many months with each person contributing in their areas of expertise. It definitely was a team effort.

Since the paper has been published, a few people have been in contact with me to share some of the bits of bone they had found at Hampden, in a couple of cases they were even billfish skull elements! It's a bit of a mystery as to why there are so many fossil billfish in this Eocene area, perhaps a future study will tackle that question. If you want to watch the video of the billfish skull being found, you can view it here:

https://www.youtube.com/watch?v=z_TfdMMFZbs

You can see the paper here:
https://www.researchgate.net/publication/396892117_Fossil_billfish_Xiphioidei_from_the_Eocene_of_Hampden_North_Otago_New_Zealand

Life in the Hot Springs

By Bruce Mountain

The steaming waters of New Zealand's thermal regions are a natural wonder – and not just because of their drama and beauty. Once thought to be empty of life, the hot springs are in fact teeming with microbes. These remarkable organisms could hold clues to the evolution of life on earth, and on other planets.

Extremophiles

Because of their high temperatures, hot springs have traditionally been regarded as devoid of life. Research during the last few decades has, however, shown that they are teeming with microbes – tiny survivors known as extremophiles.

Champagne pool, Waiotapu, North Island, home to several microbial extremophile species

Characteristics of Extremophiles

Extremophiles are organisms that live in extreme conditions of temperature, acidity, salinity, pressure, or toxin concentration.

Most extremophiles are single-celled micro-organisms belonging to two domains of life – bacteria and archaea. These differ from fungi, plants, animals and other single-celled organisms because their genetic material is dispersed through the cell rather than being enclosed within a nucleus.

Types of Extremophile

The main types of extremophile found in geothermal areas include:

- thermophiles (heat-loving)
- acidophiles (acid-loving)
- thermoacidophiles (heat- and acid-loving).

For an organism to be classified as an extremophile, it must live its entire life at these unusual conditions. Many will actually die if conditions are less extreme.

Discovering Extremophiles

In 1966 Thomas Brock showed that microscopic organisms thrived in hot springs at Yellowstone National Park, USA. Since then extremophiles have been found all over the world, and their study is one of the rapidly expanding areas of biological science. Because of its variety of thermal features, New Zealand is one of the best places to study these organisms.

Human Limits

Normal human body temperature is 37°C, and a comfortable bath temperature is about 40°C. Hotter than that, things get unpleasant and we labour to keep our temperature stable. After five seconds at 60°C, our skin will be permanently damaged. We are definitely not thermophiles.

Studying Extremophiles

From the genetic makeup of extremophiles, it is conjectured that the earliest life on earth evolved in a hot spring or deep-sea thermal vent several billion years ago. New Zealand's geothermal environments may represent similar conditions. It is also possible that geothermal environments may be similar to the conditions on other planets or moons and, if life exists in these places, it may resemble the extremophiles we see on earth.

On a practical level, extremophilic organisms are of interest because they contain special molecules such as proteins that are resistant to high temperatures and have potential applications in biotechnology.

Chickens are not extremophiles either

Microbial life in Champagne pool

How Extremophiles Survive

Unlike most organisms that require organic (carbon-containing) compounds for their energy or can carry out photosynthesis, some extremophiles can produce energy from inorganic compounds.

The hot water found in geothermal areas is formed as the result of heating of groundwater by deep heat sources. Very hot water is highly corrosive. As it moves through fractures deep in the earth it can dissolve minerals or convert them to other minerals.

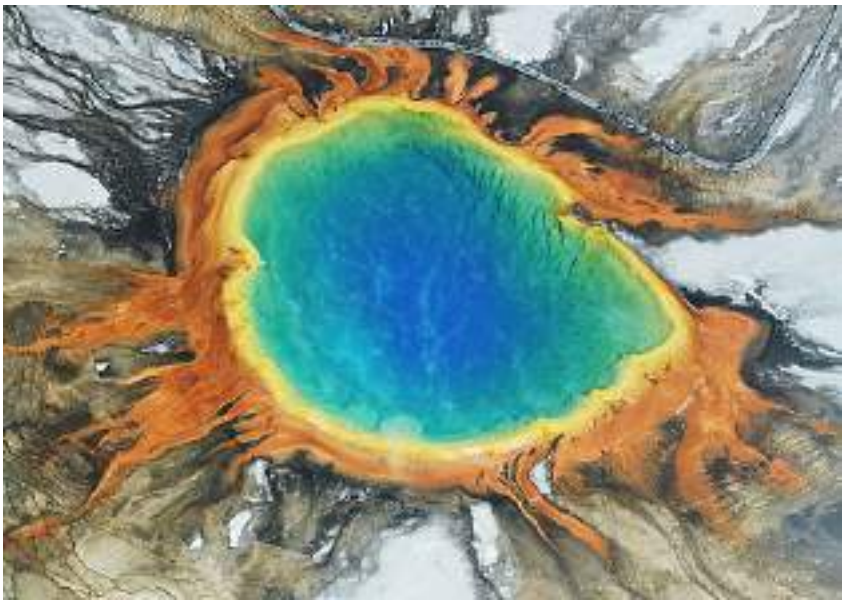
When the water reaches the surface, it forms hot spring fluids. These may contain high concentrations of dissolved chemicals such as chloride, sulfate, sodium, potassium, bicarbonate and silica. Also present are minor dissolved chemicals including calcium, iron, aluminium, arsenic, ammonia, hydrogen and hydrogen sulfide. Some of these provide the basic energy source and nutrients for a number of extremophile micro-organisms.

Thermophiles

The boiling point for water is 100°C (212° Fahrenheit). As with humans, the highest temperature at which most animals and plants can live is about 40°C. However, some insects and crustaceans are comfortable up to 50°C and some plants and fungi survive up to 60°C. Above this temperature the only organisms that can survive the heat are some groups of bacteria and archaea.

Cyanobacteria and Microbial Mats: 70°C

One group common in hot springs are cyanobacteria. They derive energy from the sun through photosynthesis, and produce oxygen much like plants. They will not grow in highly acidic waters. Their upper temperature limit is about 70°C; above this, photosynthesis cannot occur.



Thermophiles produce some of the bright colors of Grand Prismatic Spring, Yellowstone National Park

Cyanobacteria are usually green, and are found in most thermal areas throughout the world. Some cyanobacteria can be other colours because of pigments that mask the green chlorophyll. These pigments protect the bacteria from the sun's ultraviolet radiation.

Cyanobacteria in New Zealand

Floating mats of cyanobacteria are present in hot pools in most of New Zealand's geothermal areas. An exception is the Rotokawa region near Taupō, where most springs are highly acid, with very few cyanobacteria. The presence of cyanobacteria mats can therefore tell us something about the temperature and chemistry of a hot spring without having to measure it.

Thermus Aquaticus: over 70°C

Above about 70°C, only non-photosynthesising bacteria can grow, and bacterial growths tend to be less colourful and more difficult to recognise. There are, however, many species of bacteria that prefer to live at these temperatures. One is *Thermus aquaticus*, originally identified in a hot spring at Yellowstone National Park in the USA. This thermophile, now manufactured artificially, supplies the enzyme used in the technique of replicating DNA from a wide variety of sources. The discovery of Taq polymerase, as the enzyme is called, has led to a revolution in genetic research. It is also used in DNA fingerprinting of humans for forensic and other purposes.

Hyperthermophiles: over 80°C

Hyperthermophiles have adapted to contend with extremely high temperatures, and will not grow at lower temperatures. Of the three broad divisions of life (bacteria, archaea and eucarya), relatively few bacteria can live at these temperatures; most hyperthermophilic organisms are archaea.

Many hyperthermophiles are found in hot springs and around deep-sea hydrothermal vents. The first hyperthermophile to be recognised was *Sulfolobus acidocaldarius* from Yellowstone National Park, and it was later found in New Zealand hot springs.

Strain 121: Beyond Boiling Point

The organisms that are capable of surviving at the highest temperatures include *Pyrolobus fumarii* and Strain 121. Both of these species are archaea. *Pyrolobus* lives in the deep ocean around hydrothermal vents and is able to reproduce at a maximum temperature of 113°C. Strain 121, only recently discovered, is so far the record-holder with a maximum growth temperature of 121°C.

It is generally believed, although not proven, that the maximum temperature at which we might find living micro-organisms is about 150°C. In this heat the chemical bonds that make up important biomolecules such as amino acids begin to break down.

Acidophiles

Many of New Zealand's hot springs and volcanic craters are very acidic. There are many acid-loving extremophiles that thrive there, such as the alga *Cyanidium caldarium*. Unlike other algae, it is able to survive in water with pH values down to zero – close to the level of battery acid. *Cyanidium* is also a moderate thermophile and can grow in temperatures up to 56°C. Growths of *Cyanidium* are present in New Zealand geothermal areas where acid waters are found, including Rotokawa and White Island.

Lake Rotokawa, a highly acidic pool, supporting Thermodesulfobacterium and Cyanidium spp

Measuring Acidity

Scientists use the pH scale, from 0 to 14, to measure how acid or alkaline a solution is. Pure water is neutral, with a pH of 7. Values below 7 are acid, and those above are alkaline. For comparison, lemon juice has a pH of 2; sea-water is 8.2; and a concentrated ammonia solution is about 12.

Despite being able to survive extremely acid conditions, these organisms cannot tolerate such acidity inside the cell because essential molecules such as DNA become unstable. Acidophiles have evolved mechanisms to pump acids out of the cell in order to maintain weak to neutral acid conditions (pH 5–7). Many acidophiles also excrete protective, acid-resistant polysaccharides on their cell membranes.

Acidophiles and Sulfur

Most acidophilic types of bacteria and archaea grow where sulfur compounds are present. This is not surprising given that the origin of very acid conditions is usually related to the chemical transformation of sulfur.

Examples of common acidophiles are *Alicyclobacillus acidocaldarius* (a moderately thermophilic, acidophilic bacterium) and the extremely thermophilic *Sulfolobus acidocaldarius*, a member of the archaea domain.

Sinter

Micro-Organisms and Sinter

When hot springs overflow they often form layers of sinter – a rock made of very fine-grained silica – that takes the form of flats, terraces and mounds. Sinter terraces are one of the most distinctive features of geothermal areas, and provide evidence for past geothermal activity.

Sinter deposits are covered with a wide variety of complex textural features such as spicules (spike-like growths of silica) and mini-terraces. Their surfaces are also extensively colonised by micro-organisms, which in many geothermal areas show their presence by colouring the sinter. The coloration of the Pink Terraces, destroyed in the 1886 eruption of Mt Tarawera, was probably due to the presence of extensive growths of a pigmented thermophilic bacterium such as *Thermus ruber*.

How Sinter Forms

When high-temperature geothermal fluids reach the surface, they undergo drastic cooling. Much of the mineral material dissolved in these fluids can no longer remain in solution and begins to precipitate as the fluid cools.

Sinter growth smothering vegetation

The most common precipitate is amorphous silica. This is composed of silicon dioxide (SiO_2), and has no regular crystal structure. Amorphous silica forms spheres so small they cannot be seen with a microscope. These spheres stick together to coat surfaces. They continue to increase in size, forming a continuous coating of silica much like a very thin layer of glass. Amorphous silica will coat any surface, including twigs, feathers, pine cones, newspaper, bottles and micro-organisms.

Other less common minerals that can be found in New Zealand deposits include calcite (calcium carbonate), gypsum (calcium sulfate), pyrite (iron sulfide) and other metal sulfides.

Sinter and the Origin of Life

There is continuing debate among scientists about the contribution of micro-organisms to the growth and development of the many textural varieties of sinter deposits. Detailed study of sinters has shown that they are composed of thin layers of chemically precipitated silica interleaved with silicified mats and clots of thermophilic organisms. Do the organisms actively encourage silica precipitation, or are they just passive recipients of the silica?

Hand sample of laminated layers of sulphur and iron oxide sandwiched between siliceous sinter. The top surface has stalagmitic mineral growths. Collected from Lake Rotomahana

The resolution of this controversy is of great importance. The discovery of biologically generated (biogenic) sinter textures in the ancient fossil record of the earth could help us to understand the origin and evolution of life. In addition, the discovery of preserved hydrothermal deposits containing biogenic textures on extraterrestrial bodies may provide us with evidence of life beyond earth.

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